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Econ 5810.8 Bd. Apr. 1894.



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FROM

Dept. of State.

22 Jan. 1892.

U. S. — Dept. of State

SPECIAL CONSULAR REPORTS.

Vol. V.

CANALS AND IRRIGATION

IN

FOREIGN COUNTRIES.

REPORTS FROM THE CONSULS OF THE UNITED STATES IN ANSWER
TO CIRCULARS FROM THE DEPARTMENT OF STATE.

ARRANGEMENT.

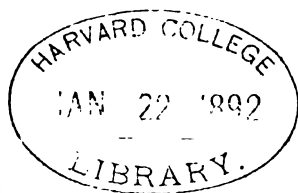
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WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1891.

~~VI 990.2~~

Econ 5810.8



CHAS. W.
VICKREY
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Dept. of State

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A COMMUNICATION
FROM
THE SECRETARY OF STATE,
TRANSMITTING

Special reports of consular officers on irrigation, canals, and port regulations.

DECEMBER 5, 1890.—Referred to the Committee on Printing.

DEPARTMENT OF STATE,
Washington, December 3, 1890.

SIR: I have the honor to transmit herewith a series of special reports, from the consular officers of the United States, on irrigation, canals, and port regulations in their several districts, covering the following phases of the subjects enumerated, viz:

Irrigation.—Areas irrigated; quantity and quality of crops grown; sources of water supply; character of works used for storage and distribution of water; systems of water distribution and cost of same to the users thereof; ownership of water; character of climate and nature of soil of irrigated regions, etc.

Canals.—The time and manner of their construction; their extent and capacity; the traffic upon them; the effect they have had in cheapening the cost of transportation; extent of the use of irrigating canals and the benefits derived therefrom, etc.

Port regulations.—Pilotage; lights and light dues; quarantine rules and regulations, etc.*

Congress appropriates \$20,000 annually for the publication of consular reports, general and special, and the reports herewith would have been published under the provisions of this appropriation, but that the general and special reports already published and being prepared for publication during the year will exhaust the same; hence the present transmittal for publication.

In this connection it may be proper to say that, in addition to the regular monthly series, the following special reports have already been published during the present year:

Cotton textiles in foreign countries; files in Spanish America; carpet manufactures in foreign countries; malt and beer in Spanish America;

* Port regulations in a separate volume.

fruit culture in foreign countries ; refrigerators and food preservation in foreign countries ; while the following are in the course of preparation : Gas and gas manufacture, lead and lead mining ; india rubber supply and manufacture of rubber goods ; tariffs of foreign countries ; and coai and coal consumption in Spanish America and the West Indies.

I respectfully request that 5,000 copies of each of the reports herewith transmitted, Irrigation, canals, and port regulations, be ordered printed for the use of the Department.

I have the honor to be, sir, your obedient servant,

JAMES G. BLAINE.

Hon. THOMAS B. REED,

Speaker of the House of Representatives.

CANAL CIRCULAR.

DEPARTMENT OF STATE,
Washington, D. C., July 31, 1889.

GENTLEMEN: The Chamber of Commerce of St. Paul, Minn., by resolution, transmitted by its president, has requested the Department to secure, through the consular officers, reports upon the canals in the several countries, viz :

The time and manner of their construction, their extent and capacity, the traffic upon them, the general management thereof, the effect they have had in cheapening the prices of transportation, etc.; also, reports showing the extent of the use of irrigating canals and the benefit derived from them.

You are, therefore, requested to prepare reports covering the foregoing subjects, adding such other information as may contribute to the complete illustration of the important matters embraced by the resolution, and to forward the same to the Department at your earliest convenience.

I am, gentlemen, your obedient servant,

WILLIAM F. WHARTON,
Acting Secretary.

The CONSULAR OFFICERS OF THE UNITED STATES.

PART I.

CANALS.

CONTINENT OF AMERICA.

DOMINION OF CANADA.

CANALS OF CANADA.

REPORT BY COMMERCIAL AGENT LEISHMAN, OF MORRISBURG.

CANAL DEVELOPMENT.

Previous to confederation the canals in Canada were owned by the provincial governments.

In 1867 the union of the provinces was effected and they became the property of the Dominion Government, subject to the control of the department of inland revenue, but their construction, maintenance, and repairs are provided for by the department of railroads and canals. The St. Lawrence and Welland Canal systems, in conjunction with the Sault Ste. Marie Canal and the Great Lakes, give an unbroken water communication from Duluth via Montreal to Liverpool, a distance of 4,618 miles, of which 71 miles are artificial navigation.

In 1841 the system of canals between Montreal and Lake Ontario was contemplated with a view of securing a depth of 9 feet at all stages of the St. Lawrence waters.

The St. Lawrence River, however, is from various causes subject to fluctuations, the extent of which it seems was not determined with precision at the time when the canals were originally constructed.

The observations and experience of subsequent years have proven that while the intermediate river affords a sufficient depth for vessels drawing 9 feet, in the canals themselves at certain periods of low water that depth can not be maintained, the bottom not having been sunk to an adequate low depth.

The Dominion canals constructed between Montreal and Lake Erie, are the Lachine, Beauharnois, Cornwall, Farran's Point, Rapide Plat, Galops, and Welland. The aggregate length of these canals is $70\frac{1}{2}$ miles, the total height overcome by locks is $533\frac{1}{2}$ feet and the number of locks is fifty-three. The greatest navigable depth is 14 feet and that at present to be found only in the Welland Canal, which was opened for the first time for 14 feet navigation during the season of 1888.

In the year 1871 it was decided by the Dominion Government to enlarge the canals on the St. Lawrence route, and it was subsequently determined that such a depth should be secured as would accommodate vessels of 14 feet draft. In conformity with this scheme of enlargement all permanent structures such as locks, bridges, etc., which are being built are required to be of such proportions as will accommodate vessels of 14 feet draft. The new locks are 270 feet long between the gates, 45 feet wide, and with a clear depth of 14 feet of water on the

sills. The walls are of dressed stone, backed up with large, flat-bedded stone, and laid throughout in hydraulic cement. The face stones are laid in regular courses, the thickest course being at the bottom and diminishing upwards in regular succession. The foundation timbers are pine 12 inches square and covered with two thicknesses of planks.

LACHINE CANAL.

The Lachine Canal is located on the northern side of the St. Lawrence River. It extends from the city of Montreal to the village of Lachine, and was constructed to overcome the St. Louis rapids. It is $8\frac{1}{2}$ miles in length, has five locks, and a total lockage or rise of 45 feet. Its mean width is 150 feet. It consists of one channel with two distinct systems of locks, the old and the enlarged. Its present navigable depth is 12 feet, but with the excavation of the canal prism to a further depth of 2 feet it will accommodate vessels of 14 feet draft. A portion of this canal is lighted by electricity. Its construction consists of the excavation of earth and rock, and the manner of letting the work is by public tenders. The work on this canal was commenced in 1821, and the first vessel passed through it in 1825.

BEAUHARNOIS CANAL.

This canal commences $15\frac{1}{2}$ miles west from the head of the Lachine Canal. It is on the south side of the St. Lawrence River and connects Lakes St. Louis and St. Francis and passes the three rapids known respectively as the Cascades, the Cedars, and the Coteau. Its length is $11\frac{1}{2}$ miles, the number of locks is nine, and their dimensions are the old size, 200 feet long and 45 feet in width. The total rise or lockage overcome is $82\frac{1}{2}$ feet; the navigable depth is 9 feet; the breadth of the canal bottom is 80 feet, and its breadth at the water surface is 120 feet. Opened in October, 1845, for navigation.

CORNWALL CANAL.

The Cornwall Canal was commenced in 1834 and opened for navigation in 1842. It is situated on the north side of the St. Lawrence, opposite the village of Cornwall, and commences $32\frac{3}{4}$ miles from the head of the Beauharnois Canal. It extends past the Long Sault Rapide. It is the longest canal on the St. Lawrence, being $11\frac{1}{2}$ miles in length, has six locks, two of which are the new or enlarged size. The total rise or lockage overcome is 48 feet. The navigable depth is 9 feet. Its breadth at the bottom is 100 feet and at the water surface 150 feet. Four new locks are under contract and are now in the actual course of construction, together with the supply weirs and bridges, also the enlarging and deepening of the canal prism. Its water is utilized for motive power by varied and extensive manufacturing industries. This canal was formed by excavation and crib work.

WILLIAMSBURG CANALS.

The Farran's Point, Rapide Plat, and Galops Canals, are collectively known as the Williamsburg Canals. They are situated on the north shore of the St. Lawrence River and were constructed to overcome certain rapids, the names of which they bear. They were formed by cutting through projecting points, and with the material removed inclosing bays, and indents in the shore line, making a continuous range of bank

between the river and the canal. Wherever required by the swiftness of the current, the depth of water, or other circumstances, the bank is made solid by a line of rough crib work, and along the outer side of the bank as well as the two inner sides of the canal a wall of broken stone has been built to prevent the washing of the sides. The channel is 50 feet wide at the bottom with side slope, with 2 horizontal to 1 vertical. The breadth of the canal is 90 feet at the surface of the water, and is navigable for vessels of 9 feet draft. The Farran's Point Canal is the first of the division in ascending the river. It commences 5 miles from the head of the Cornwall Canal. It was opened in 1847, is three-fourths of a mile in length, has one lock, with a lockage or total rise of 4 feet. Its banks vary from 15 to 38 feet high over the water surface.

Rapide Plat Canal is the second of the series and is located opposite the village of Morrisburg. It commences $10\frac{1}{2}$ miles from the head of Farran's Point Canal. It was first opened for navigation in September, 1847. It is 4 miles in length, has two locks, and a total rise or lockage of $11\frac{1}{2}$ feet. The enlargement of this canal in conformity with the proportions of the general scheme has been commenced. The work already accomplished consists of the enlargement of the channel way above and for some distance below the guard lock at the head of the canal, and the construction of a new lock and a supply weir in connection with the old lock. Arrangements are in progress for the enlargement of the lower portion of the canal, consisting of the prism and lock at the canal outlet. Soundings have been taken and specifications are being prepared with a view of advertising the work for public tenders. The Galops Canal commences $4\frac{1}{2}$ miles from the head of Rapide Plat Canal. It is $7\frac{5}{8}$ miles in length, has three locks, and a total rise or lockage of $15\frac{3}{4}$ feet. It was first opened October, 1847. The new work completed on this canal consists of the deepening of a channel way at upper end, greatly facilitating access to the canal.

The Welland Canal connects Lake Erie with Lake Ontario. It is $26\frac{3}{4}$ miles in length, extending from Port Colborne to Port Dalhousie. It has twenty-six locks and a total rise or lockage of $326\frac{3}{4}$ feet. Its construction was commenced by an incorporated company. The first sod was turned November 30, 1824. The company's financial resources proved inadequate to the constantly large outlay that was necessary to maintain the canal in the efficient condition its importance required, and in 1841 an act was passed authorizing its purchase by the Government. This canal was opened for navigation in 1841. It has gone through several subsequent changes, the tendency of which has been to greatly increase its depth and dimensions.

SELLAR LEISHMAN,
Commercial Agent.

UNITED STATES CONSULATE,
Morrisburg, September 30, 1889.

BURLINGTON BAY CANAL.

REPORT BY CONSUL ROBERTS, OF HAMILTON.

The only canal within my consular district is a short one about half a mile in length, connecting Lake Ontario with Burlington, or Hamilton Bay, through a narrow strip of sandy beach which divides the waters of the bay from the lake, and this short canal, which has no locks, gives

access to the port of Hamilton. The act of Parliament authorizing its construction was passed in 1823, and the canal required nearly 9 years in its construction. Upon its completion, in 1832, Hamilton became the head of navigation on Lake Ontario.

The construction of the Desjardines Canal, running from the head of Burlington Bay to Dundas, engaged the attention of the people of Dundas and Hamilton about this time. It was chartered in 1816, and completed in 1832, the same year that witnessed the completion of the Burlington Bay enterprise. For years the Desjardines Canal did a large business, but the subsequent construction of the Great Western or Grand Trunk Railway rendered this canal practically useless. The abolition of tolls on the Burlington Bay Canal was advocated by a local board of trade as early as 1840, and continued with such persistence that the tolls were finally abolished, being regarded as an irksome impost, productive of a steadily diminishing revenue, and serving only the purpose of driving shipping away from the port.

There are two stationary lights on vertical piers at the canal, one at the extreme end of the south pier on the lake, and the other about midway of the canal where it is crossed by the Northwestern Railway by means of a turn bridge.

To the Hon. H. B. Witton, inspector of canals, I am indebted for the following brief history of the canal, accompanied with categorical answers to the inquiries submitted in the circular:

When the bill was passed for the construction of the canal in 1823, commissioners were appointed and contractors agreed for \$34,000 to complete it by 1825, but it was not reported as finished until 1832. Since then the piers which extend the canal into the lake and bay have been lengthened and the channel deepened at a total cost of more than \$500,000.

Length of canal $\frac{1}{2}$ mile; average width between piers, 138 feet; navigable for vessels drawing 14 feet of water; average traffic 125,000 tons per annum.

The management is under control of the department of railways and canals. It has been a serviceable check on the rates of freight to and from the port of Hamilton.

ALBERT ROBERTS,
Consul.

UNITED STATES CONSULATE,
Hamilton, August 7, 1889.

THE WELLAND CANAL.

REPORT BY CONSUL WHELAN, OF FORT ERIE.

HISTORY OF CONSTRUCTION.

The Welland Canal, running with and south through the consular district, and connecting the waters of Lake Erie with those of Ontario, owes its origin, in great part, to the enterprise and perseverance of William Hamilton Merritt, who was born in the State of Massachusetts, in 1793. Like many of the early settlers of this section, known as "United empire loyalists," his parents emigrated to Canada shortly after the Revolutionary war.

In 1818, when Mr. Merritt had grown to manhood, he was, among other things, engaged in the milling business, in the neighborhood of what is now the city of St. Catharine's. A scarcity of water during the summer seasons led him to investigate and make a rough survey, in order that he might find an ample supply for his mills.

Then he conceived the idea of uniting the two lakes by a canal across

the Niagara peninsula, by which a full and never-failing supply of water would be obtained, the obstructions to Niagara River navigation turned and overcome, and the cities of Montreal and Quebec made successful rivals of New York and other competing Atlantic ports. As in the case of all great undertakings, there were forebodings of disaster and loss of investment, opposition, and manifold difficulties, and the project was apparently abandoned. But Mr. Merritt's tireless energy never slumbered, and in 1824 he succeeded in organizing and in having incorporated the Welland Canal Company, with a capital of £40,000. Mr. George Keeper was chosen president; Mr. Merritt was made financial agent, and proceeding to Montreal, New York, and other places, succeeded in enlisting capitalists in the undertaking, and in raising sufficient funds with which to commence work.

The first sod was turned on November 30, 1824, but the work proceeded slowly owing to the difficulty of procuring money as needed. In 1826 the legislature of Upper Canada made a grant to the company of 13,000 acres of land in the neighborhood of the canal, and empowered the government to take stock to the amount of £40,000. The legislature of the Lower Province and also the British Government rendered some assistance to the company; and in 1829 the work had so far progressed that two schooners—the *Anne and Jane* of Toronto, and the *R. H. Houghton* of Youngstown, N. Y.—passed up the canal to Port Robinson, were there locked into the Welland River, and proceeded by way of Chippewa to Buffalo. The canal, as originally laid out, was completed in 1833, but, it seems, required further and large expenditures for needed improvements and repairs.

In 1842 the Canadian government bought of the company all its interest and stock in the canal, and, assuming the sole control and management, immediately commenced improvements. The main line of the old canal was $27\frac{1}{2}$ miles long, with a total rise or lockage of $326\frac{3}{4}$ feet and a depth of water of 10 feet. It had 26 lift-locks and 1 guard lock. In 1870 the government found it necessary, in the interest of commerce, to enlarge the canal throughout. From Port Dalhousie, the Lake Ontario entrance, south to Allanburgh, a distance of $11\frac{3}{4}$ miles, a new channel was dug, connecting with the old line at the latter place; so that from Port Dalhousie to Allanburgh there are now two distinct lines of canal. From Allanburgh to Port Colborne the old canal was enlarged.

The Welland has one entrance from Lake Ontario serving for both the old and new canals, and two from Lake Erie, one for the main line at Port Colborne, and one for the feeder at Port Maitland, 18 miles farther up the lake; it also has an entrance from the Niagara River at Chippewa. The main and enlarged line is that between Port Dalhousie and Port Colborne; it is $26\frac{3}{4}$ miles long and 100 feet in width at the bottom, with a depth of water throughout of 14 feet; it has 25 lift locks, each 45 feet by 270. The feeder is 21 miles in length, has 2 locks, and a depth of 9 feet of water. The new aqueduct at Welland, through which the waters of the canal are conveyed over the Welland River, is a stupendous work of massive stone masonry. It is about 422 feet in length, and its breadth is 120 feet; its channel is 86 feet wide, the bottom being 5 feet below the low-water line of the river, which passes under the aqueduct through 6 arches, each of 40 feet span.

Besides the new aqueduct, the enlargement involved the building of 18 road bridges, 5 railway bridges, 7 culverts to carry the waters of small rivers under the canal, 1 culvert for a roadway and the Grand Trunk Railway tunnel, which is 665 feet long, 16 feet wide, and 18 feet

high. The enlargement is estimated to have cost \$16,000,000; thus making more than \$23,000,000 expended by the imperial, provincial, and dominion Governments, on the construction and enlargement of the canal.

It is under the control of the Dominion Government, and is managed by engineers, a superintendent, and collectors at various points along the route. Many mills and factories along the line are supplied with water-power, and the revenue from this source amounts to about \$4,000 a year.

The toll on flour and grain passing eastward down the Welland is 20 cents per ton, but on proof of delivery of the cargo at Montreal, or any other Canadian port east of Montreal, by orders in council at various times passed, a refund of 18 cents per ton is made, discriminating to that extent in favor of Canadian ports.

CANAL VS. RAILROAD TRANSPORTATION.

The value of the Welland Canal is inestimable as a link in the system of inland navigation in Canada, extending 2,260 miles, from Port Arthur, on Lake Superior, to the Straits of Belle Isle, on the north Atlantic coast. It is doubtless a potent factor in the fixing of freight charges, for, did it not exist, the railroads would certainly impose upon traffic such rates as they might conclude it would bear.

Table showing the tonnage of flour, wheat, corn, barley, oats, rye, and other articles of vegetable food cleared down (east) on the Welland during a series of thirteen years ending December 31, 1884.

Year.	Tons.	Year.	Tons.
1872.....	524, 889	1879.....	430, 795
1873.....	563, 813	1880.....	417, 853
1874.....	620, 933	1881.....	235, 753
1875.....	374, 962	1882.....	275, 594
1876.....	384, 807	1883.....	355, 335
1877.....	448, 931	1884.....	288, 752
1878.....	389, 296		

Statement of the quantity of flour, wheat, corn, barley and oats passed (east) down the Welland Canal during the fiscal years ended June 30, 1885, 1886, 1887, and 1888, showing from what ports to what ports.

Year.	Canadian to Canadian.	Canadian to United States.	United States to United States.	United States to Canadian.	Total.
	Tons.	Tons.	Tons.	Tons.	Tons.
1885.....	25, 227	199	110, 810	137, 857	274, 093
1886.....	32, 020	423	138, 256	161, 596	332, 295
1887.....	30, 485	.....	147, 235	162, 266	339, 986
1888.....	54, 469	.....	166, 043	163, 451	383, 963

Statement of tonnage of vessels and property passed eastward (down) through the Welland Canal during the fiscal years ended June 30, 1883, 1884, 1885, 1886, and the season of 1887.

Year.	Tonnage of vessels.	Tonnage of property.
1883.....	385, 518	541, 790
1884.....	435, 332	608, 303
1885.....	362, 520	494, 507
1886.....	422, 511	599, 542
1887.....	319, 361	484, 896

Statement of traffic through the Welland, up and down, from 1882 to 1886, both inclusive.

Year.	Tonnage of vessels.		Total tonnage.	Freight.
	Canadian.	United States.		
1882.....	516,484	162,556	679,040	<i>Tons.</i> 608,929
1883.....	471,274	276,922	748,196	827,196
1884.....	489,021	362,330	851,351	940,120
1885.....	402,914	847,277	750,191	826,961
1886.....	465,286	358,928	824,014	914,478

Tonnage of property passed through the Welland Canal, up and down, during the fiscal year ended June 30, 1885, 1886, 1887, 1888.

Year.	Property up.	Property down.	Total.
	<i>Tons.</i>	<i>Tons.</i>	
1885.....	332,364	494,497	826,961
1886.....	814,936	599,542	914,478
1887.....	262,978	561,984	824,962
1888.....	273,484	553,816	827,300

Amount of tolls collected on the Welland Canal for a period of six years commencing 1882.

Year.	Tolls collected.	Year.	Tolls collected.
1882.....	\$108,640	1885.....	\$151,690
1883.....	154,077	1886.....	173,984
1884.....	176,165	1887.....	157,212

JAMES WHELAN,
Consul.

UNITED STATES CONSULATE,
Fort Erie, September 28, 1889.

WELLAND, RIDEAU, AND ST. LAWRENCE CANALS.

REPORT BY CONSUL TWITCHELL, OF KINGSTON.

I have spent considerable time in vain endeavoring to secure more information of the building and enlargement of the Welland, Rideau, and Lower St. Lawrence Canals. These canals are the only ones which affect trade and transportation in an observable degree at Kingston.

RIDEAU CANAL.

The Rideau Canal was built by the Government very early in the history of Canada as a means of transporting military supplies from Lower to Upper Canada in case the St. Lawrence should be blockaded. Its use is now very valuable to the country through which it runs for marketing cheap lumber and commodities which will not bear expensive transportation. This canal was commenced in 1824 and completed in 1832, with locks which will pass vessels of 180 tons.

WELLAND AND ST. LAWRENCE CANALS.

The Welland and St. Lawrence Canals, completed in 1845 and enlarged to their present size in 1880, with a capacity to pass vessels of 1,500 tons, open a complete water route from the grain-producing north-west to the ocean. For 6 months in the year this water route and the railroads north and south of it are in direct competition. The season now passing will doubtless exceed any preceding year in the amount of grain passing out to the ocean by this route.

Table showing the tonnage of the undermentioned articles of vegetable food cleared downwards on the Welland Canal, during a series of eighteen years, ended December 31, 1888.

Year.	Flour.	Wheat.	Corn.	Barley.	Oats.	Rye.	Other articles.	Total.
	<i>Tons.</i>	<i>Tons.</i>	<i>Tons.</i>	<i>Tons.</i>	<i>Tons.</i>	<i>Tons.</i>	<i>Tons.</i>	<i>Tons.</i>
1869 [*]	44, 110	310, 090	119, 541	3, 920	.....	680	1, 541	479, 882
1872.....	26, 648	231, 056	254, 534	2, 693	7, 504	61	2, 300	524, 899
1873.....	30, 660	345, 720	180, 042	2, 643	1, 188	3	3, 557	563, 813
1874.....	24, 017	406, 157	181, 128	377	5, 953	.....	3, 201	620, 938
1875.....	13, 980	248, 555	103, 477	813	3, 383	500	4, 304	374, 062
1876.....	15, 735	194, 559	144, 501	1, 110	24, 496	1, 454	2, 949	384, 807
1877.....	13, 588	248, 894	169, 185	10, 216	2, 810	2, 405	1, 833	448, 931
1878.....	8, 854	188, 106	185, 931	1, 217	3, 088	.....	2, 100	389, 296
1879.....	10, 588	271, 546	144, 276	808	1, 196	.....	2, 387	430, 795
1880.....	12, 467	240, 601	162, 891	.....	477	.....	1, 418	417, 853
1881.....	9, 655	121, 393	103, 075	252	.....	6	1, 371	235, 752
1882.....	12, 205	205, 876	54, 797	537	.....	1, 954	225	275, 594
1883.....	13, 256	146, 741	182, 143	975	731	518	10, 971	355, 335
1884.....	13, 626	135, 804	118, 811	279	10, 746	477	9, 018	288, 752
1885.....	13, 322	114, 090	117, 536	618	1, 116	.....	1, 628	248, 310
1886.....	19, 418	146, 151	218, 897	.....	4, 891	.....	14, 571	403, 928
1887.....	23, 940	210, 755	114, 938	1, 711	12, 050	.....	12, 149	375, 543
1888.....	16, 973	150, 833	194, 886	555	26, 629	811	13, 358	404, 045

^{*}Fiscal.

CANAL VS. RAILWAY TRANSPORTATION.

In searching for the effect of this water route on transportation I find that the railroads parallel to the water route charge 24 cents per hundred for moving first-class freight 100 miles; the roads running at right angles to the water route charge 44 cents for the same service. As soon as lake transportation becomes dangerous, rates on these parallel railroad lines are advanced.

CANAL CONTROL.

The canals are all built, repaired, and controlled by the Government which by its system of tolls encourages vessels to use the entire water route from the lake to the ocean.

CANAL TOLLS.

Vessels going down through the Welland Canal receive a receipt for the toll paid, which is taken up by the Government and 90 per cent. of the money returned to the vessel upon satisfactory evidence being furnished that the grain upon which the toll was paid has passed through the St. Lawrence Canal and out of the country. If the grain leaves the water route for consumption or transportation the vessel loses the advantage of the return of the toll.

CANAL RECEIPTS AND EXPENSES.

The Government received last year for canal tolls, after deducting the rebate, \$271,722.24, which, it is thought, will but little more than pay the running expenses.

This, with the best information which I can get of the intentions of the Government, indicates that the canal system of Canada is inaugurated and sustained entirely for the benefit of the public.

M. H. TWITCHELL,
Consul.

UNITED STATES CONSULATE,
Kingston, November 14, 1889.

THE CANAL SYSTEM OF CANADA.*

REPORT BY CONSUL-GENERAL STEARNS, OF MONTREAL.

The St. Lawrence River, and the Great Lakes, whose waters flow through it into the Atlantic, form a continuous water way extending from Fond du Lac, at the head of Lake Superior, to the straits of Belle Isle, a distance of 2,384 miles. Along its course at convenient distances is abundant water power, and in its numerous bays and inlets are safe and commodious harbors.

Emptying into the St. Lawrence and contributing to the volume of its waters, as well as to the importance of its trade, are the Ottawa and Richelieu Rivers, the former bringing it into communication with the immense lumber forests of Ontario, and the latter connecting it with Lake Champlain in the United States. These rivers were the thoroughfares in peace and the base lines in war for the Indian tribes long before the white man appeared on the Western Hemisphere. Upon their broad bosoms the first explorers and voyagers pushed their adventurous way into the heart of this Northern country, and opened it to commerce and civilization.

The early colonists of Canada found them the convenient and almost the only channels of intercourse among themselves and with the home country. Supplies were brought up the St. Lawrence in seagoing vessels to Quebec and Montreal, and thence distributed to the scattered settlements throughout the country.

Indian canoes, richly laden with furs and pelts, and later, batteaux and Durham boats, freighted with the surplus grain of the colonists, and lumber rafts from the Upper Ottawa and the lakes, floated down the Ottawa and the St. Lawrence to Montreal, Three Rivers, and Quebec, when their cargoes were exchanged for the comforts and necessities of life brought from France. The St. Lawrence was navigable for seagoing vessels as far as Montreal, but between Montreal and the foot of Lake Ontario there was a succession of rapids separated by navigable reaches. On account of the rapidity of the current these rapids are impassable to boats of any size ascending the river, but most of them can be passed on the downward trip by vessels not too heavily loaded and built strongly enough to resist the strain of the whirling waters.

The head of navigation on the Ottawa River is the city of Ottawa, now the capital of the Dominion, but formerly known as Bytown. Be-

* From Consular Reports, No. 42, June, 1884.

tween this city and the mouth of the river at the southern extremity of the Island of Montreal there are several impassable rapids.

The Richelieu, which is, as I have said the outlet of Lake Champlain, was also so much obstructed at various points as to be unavailable for navigation.

A list of the various rapids on the St. Lawrence, Ottawa, and Richelieu, with a statement showing their length and that of the navigable reaches between them, will be found in Appendices A, B, and C.

The canal system of Canada, both in its entirety and its separate parts, has been established to overcome these obstructions, and, by artificial channels at various points, to render freely navigable the natural routes of transportation. By means of it the whole St. Lawrence system, from Lake Erie to the sea, has been made passable by a connecting chain of canals, comprising 71½ miles of artificial navigation, the least depth of which is 9 feet; a line of communication established between the St. Lawrence at Montreal and Lake Ontario at Kingston, by way of the Ottawa and the Rideau River, and a passage opened from the St. Lawrence to Lake Champlain and the United States.

The history of the efforts put forth to accomplish results so creditable to the enterprise and liberality of the people of Canada is an interesting and instructive one, and this report will consist of a résumé of its salient points, with such statistical information as may pertain to it, and a statement of the present condition and future prospects of the system.

For convenience, and because of their relations to each other, the canals thus constructed are grouped in official reports, and by those who have written upon them, under five heads, viz :

- (1) The St. Lawrence Navigation.
- (2) The Richelieu and Lake Champlain.
- (3) The Montreal and Kingston.
- (4) The Upper Ottawa.
- (5) The River Trent.

While I shall not follow these divisions, but rather the chronological order, in treating of the subject, I shall have occasion to refer to them from time to time, and it will aid in understanding what I say if they are kept in mind.

THE ST. LAWRENCE NAVIGATION.

Before the commencement of the present century, and during the period of French ascendancy, locks, or more properly small canals with locks, had been constructed by the French at the Faucille, the Trou du Moulin, Split Rock, and Coteau du Lac to overcome the Cascades, Cedar and Coteau Rapids between Lakes St. Louis and St. Francis on the St. Lawrence River. These canals were from 6 to 7 feet wide, had a depth of 2½ feet on the miter sills of the locks, which were built of stone and were designed for boats and bateaux capable of carrying from 30 to 40 barrels of flour.

A little later a channel with 2½ feet of water was obtained around the Sault St. Louis or Lachine Rapids by removing obstructions from the St. Pierre River, a small stream running across the marsh now traversed by the Lachine Canal, but this channel seems to have been of little practical use.

From about the same date until the construction of what is now known as the Cornwall Canal, bateaux were able to ascend the Long Sault Rapids, upon Lake St. Francis, by means of two small locks, one of which was situated near the village of Moulinette, and was con-

structed and maintained by Adam Dixon, a merchant of that village. But after the conquest of Canada by the British, and its division into the Upper and Lower Provinces, the country above Montreal became more thickly settled, and as the land was brought under cultivation and the crops more than met the wants of the inhabitants the question of the best method of securing for their surplus products cheap and expeditious transportation to tide water, and thereby stimulating immigration and settlement became a very important one.

Both the upward and downward trade was very much embarrassed by the difficulties and delays of the passage. In coming down the boats could, it is true, carry full loads, and the loss of time and danger at the rapids, while sufficiently great to be a serious incumbrance to commerce, were inconsiderable when compared with what was experienced on the upward trip. Ascending freight had to be hauled from Montreal to Lachine and then loaded on boats, which could not carry above 8 tons, and generally started in companies and kept close together that the crews might help one another in pushing up against the swift current. At the foot of some of the rapids the whole cargo had to be unshipped and carted to the next navigable reach, while at others the same course had to be pursued with a greater or less part of the freight that the boats might be sufficiently lightened to enter the small locks, which afforded the only means of passing the obstructions.

The average time between Lachine and Kingston on the upward trip was 12 days, and the actual expenses of a Durham boat, with an average cargo of 8 tons, was about \$26.50 per ton.

The time occupied in coming down was, of course, much less, not usually exceeding 4 days, and the expense proportionally smaller. The vexatious delays, and the additional expenses of the many portages, and the frequent transshipments from boat to cart and from cart back to boat were discouragements to trade too grave to be longer submitted to by the enterprising and energetic men who were transforming the wilderness of Upper Canada into fruitful farms and lining its available streams with saw and grist mills.

In 1804 the government of Lower Canada completed a 3-foot channel through the Lachine Rapids, close to the north shore, by which boats could be dragged or poled from Montreal to Lachine.

At about the same time the Imperial Government, primarily for military purposes, enlarged, reconstructed, and put into more advantageous positions the old French locks at Split Rock and Coteau du Lac, and built a new canal nearly half a mile in length, with three locks, around the cascades, instead of the old locks at the Fauille and the Trou du Moulin. In 1805 and 1806 Lower Canada appropriated \$8,000 for the improvement of navigation on the St. Lawrence, and some work was done at various points, mainly in dredging.

During the war of 1812 the construction of a canal to connect Montreal with Kingston, at the foot of Lake Ontario, by way of the Ottawa River, was agitated as a military measure, and various plans and routes were proposed.

The Imperial Government urged upon the provincial authorities the desirability of prosecuting the work and offered to aid them by an appropriation of £70,000; but the return of peace took away the immediate necessity for military works, and the people were unwilling to assume the burden of constructing this canal. The public men of Canada, and those interested in the commerce of the province, felt that the St. Lawrence route was destined to be the most important contributor to the commercial prosperity of the country, and that any money that could

be spared from its slender resources for internal improvements could be most profitably spent on the St. Lawrence between tide water and Kingston.

In 1815 the legislature of Lower Canada passed a bill granting the promoters of a scheme to build a canal around the Lachine Rapids a sum of money in aid of its construction, and in 1818 a joint commission, constituted by the governments of Lower and Upper Canada, and representing each, made a very instructive report in which they recommended that canals should be built at the Lachine Rapids and between Lake St. Francis and Lake St. Louis, and at the rapids above Lake St. Francis.

In 1819 the above-mentioned bill was repealed and another was passed, incorporating a joint stock company for the same purpose, with a capital of \$600,000; and in the same year another company with a smaller capital was chartered to construct what is now known as the Chambly Canal around the Chambly Rapids in the Richelieu River. In 1817 the locks between Lakes St. Louis and St. Francis were enlarged by the Royal Staff Corps from 6 to 12 feet in breadth, and the depth of water on sills was increased from $2\frac{1}{2}$ to $3\frac{1}{2}$ feet, so as to admit bateaux and Durham boats capable of carrying 100 barrels of flour. The amount expended on these works can not be ascertained, as all record thereof was destroyed by fire.

THE LACHINE CANAL.

The joint stock company, whose incorporation in 1819 for the construction of the Lachine Canal was noted, caused extensive surveys and estimates to be made, but was obliged for want of money to petition the government of Lower Canada to assume the further prosecution of the undertaking. In 1821 the act incorporating the company was repealed, and the government was empowered by provincial statute (George IV, chapter 6) to construct the Lachine and Montreal Canal as a provincial work. The design which had been recommended by the company's engineers was adopted by the government; commissioners were appointed to carry on the work in accordance therewith; ground was broken on the 17th July, 1821, and the canal was completed and opened for traffic in 1825.

The canal, as then built, extended along the north side of the river from the outskirts of Montreal to the village of Lachine. It was 8 miles and 718 yards in length, 28 feet in breadth at the bottom; at the water surface, 48 feet in earth and 36 feet in rock, and had 5 feet depth of water. There were seven locks, built substantially of stone, 100 feet long and 20 feet wide, and of a depth sufficient for vessels drawing $4\frac{1}{2}$ feet of water.

The excavations were principally through earth, with a cutting about 1 mile in length at the Lachine end through a limestone formation.

The total cost was \$438,404.15, all of which but \$40,000, contributed by the Imperial Government to secure free passage of military stores, etc., was paid by the government of Lower Canada. Of the amount paid by the province a small part was probably derived from tolls, as the loans authorized by the various acts amounted only to \$388,000.

OTTAWA CANALS.

In 1819 the Imperial Government began the construction of a series of three short canals designed to overcome the Long Sault and other

rapids on the Ottawa River above St. Anne's. They were all on the north side of the river, and, like the Rideau Canal hereafter referred to, were built by the royal staff corps, and were intended to form a part of the inland system of communication between the lakes and Montreal which the Imperial Government had determined to establish for military purposes, and which the construction of the Rideau Canal would complete.

GRENVILLE CANAL.

The Upper or Grenville Canal overcomes the Long Sault Rapids, and was the first of the three built. The original plan contemplated locks corresponding in size to those on the old Lachine Canal. Three were commenced and completed upon this scale, but the other four were built upon the enlarged scale adopted in the mean time for the Rideau Canal.

The channel was excavated partly through solid rock and partly through dirt. It was $5\frac{1}{2}$ miles long, from 20 to 30 feet wide on the bottom, and 25 to 60 feet at the surface. There were seven locks, four about 128 feet long and 32 feet wide, and three, at the upper end, about 107 feet long and 19 feet wide, with a depth of 6 feet of water on the sills.

The capacity of the Ottawa route from Montreal to Kingston as originally established was limited by the dimensions of these three locks, which could only admit vessels of about 95 feet in length by $18\frac{1}{2}$ feet in breadth.

CHUTE À BLONDEAU CANAL.

The Middle or Chute à Blondeau Canal, overcoming the rapids of the same name, was commenced somewhat later than the Grenville Canal and completed in 1832. It was cut through solid rock, was one-eighth of a mile in length, and 30 feet wide at top and bottom. There was one lock $130\frac{1}{8}$ feet long, $32\frac{1}{8}$ wide at the upper end and $36\frac{1}{2}$ feet wide at the lower end, with 6 feet of water on the sills.

CARILLON CANAL.

The Lower or Carillon Canal overcomes the Carillon Rapids, and was commenced at about the same time as and completed a year later than the Chute à Blondeau Canal. To avoid expensive excavations a summit level was made and water supplied to the canal from a neighboring tributary of the Ottawa through a feeder .62 mile long. This canal was $2\frac{1}{2}$ miles long, 30 feet broad on the bottom, and 50 feet at the water surface. The locks were three in number, two of them rising and one falling; one of the lift locks was 128 feet long and $32\frac{1}{2}$ feet wide, and the other and the guard lock were $126\frac{1}{2}$ feet long and $32\frac{1}{2}$ feet wide; all three had 6 feet of water on the sills. The original cost of this series of canals can not be even approximately ascertained, as all papers relating to their construction were burned in Montreal in 1852.

RIDEAU CANAL.

In further pursuance of the scheme in accordance with which the foregoing works had been commenced, the Imperial Government began in September, 1826, the construction of a canal from the city of Ottawa, then the inconsiderable village of Bytown, at the head of navigation on

the Ottawa River, to Kingston, at the lower end of Lake Ontario. This work, now known as the Rideau Canal, consisted in the conversion of the Rideau and Cataragui Rivers, two obstructed and rapid streams, into one continuous, navigable channel. The headwaters of the two rivers were separated by a portage of a little more than a mile in width.

The Rideau, following a tortuous course of 86 miles, and flowing with a comparatively slow and easy current through a gradually deepening channel, finally discharges itself by an abrupt and almost perpendicular fall of 45 feet into the Ottawa River near the city of Ottawa. The Cataragui winds its devious way in the opposite direction for a distance of 45 miles, and empties into Lake Ontario at Kingston.

The method of construction adopted was the conversion of a ravine, which ran into the Rideau about 2 miles above its mouth, into a canal, with eight locks, and so overcoming the Rideau falls; raising the waters of the Rideau and Cataragui for the remaining distance by a series of high dams, and supplementing them by short canals at various points where the obstructions were too large to be overcome by the slack water. After various modifications, during the progress of operations, in some of the details of the plan, the work was finally completed and opened for traffic in September, 1832. The whole route was $126\frac{1}{2}$ miles long, but only $16\frac{1}{2}$ of it was canal proper. The breadth of the canal was at bottom 60 feet in earth and 54 feet in rock, and at the surface 80 feet in earth, and the navigable depth of the whole work was $4\frac{1}{2}$ feet.

There were 47 locks—33 being ascending and 14 descending, going from Ottawa to Kingston—134 feet long and 33 feet wide, with 5 feet of water on the sills, and a total lockage of $446\frac{1}{2}$ feet, $282\frac{1}{2}$ rise and 164 fall. There were 24 dams, 11 of which were of cut stone, and the remainder of wood and clay. The stone dams were from 5 to 60 feet in height, and those of wood and clay from 6 to 45 feet. The works were constructed in the most thorough and substantial manner, under the direction of Colonel By of the Royal Engineers. The total cost of the undertaking, including the land expropriated, was \$3,911,701.47, which was borne by the Imperial Government.

This canal, with the three canals on the Ottawa, before described, and the lock afterwards built at St. Anne's, formed the Montreal and Kingston route, and furnished a continuous inland water way between the two places. They were built, as has been stated before, primarily for military purposes to secure communication between the Lower St. Lawrence and Lake Ontario, by a line farther back from the boundary between Canada and the United States, and less exposed in case of war than the St. Lawrence route. They were originally called and are still named in official papers "The Ordnance Canals."

The war office of the Imperial Government retained control of them, and bore the expense of their maintenance until the year 1857, when, after much negotiation, they were transferred to the board of public works of United Canada.

RIVER TAY NAVIGATION.

The river Tay falls into the Rideau at the foot of Lower Rideau Lake. About 8 miles from its mouth is the flourishing town of Perth. In 1831, a company was incorporated to improve the navigation of this river. The works were immediately commenced and were finished in 1834. They consisted of five locks with dams and slides. Four of the locks were of stone and the other was of wood. They were 101 feet long and 20 feet wide, had a depth of 4 feet on the sills and a lockage of 28 feet.

The total length of the channel was $8\frac{1}{2}$ miles. The cost of these improvements was \$17,764.05, of which \$7,764.05 was loaned by the government of Upper Canada and never repaid. The works have long since fallen into decay and disuse.

Very lately a survey has been made, having in view the construction of a short canal to connect the town of Perth with the Rideau Canal, and so secure for the town communication with the various canal systems.

OTTAWA RIVER NAVIGATION.

The Ottawa River, at its junction with the St. Lawrence, is divided into four distinct channels. Two of them pass back of the island of Montreal and divided by the Ile Jesus, discharge into the St. Lawrence below the city of Montreal. The other two, and the only ones used for navigation, flow on each side of an island known as Ile Perrott, which lies between the mainland and the upper end of the island of Montreal and empty into the expansion of the St. Lawrence called Lake St. Louis, a few miles above the Lachine Rapids.

Vaudreuil lock.—In these latter two channels are the first obstructions to navigation on the Ottawa. The upper of them, although affording a more circuitous route, was in its natural state passable at all stages of water for boats of moderate size, and to make it still more available, a lock large enough to pass a steamer of twenty horse power was built between the village of Vaudreuil on the mainland and Ile Perrott as early as 1816. This lock was reconstructed in 1832-'33, on the same scale as the locks of the Grenville Canal, and was maintained as a private work until the completion of the lock at St. Anne's, in the lower channel, when it was abandoned.

St. Anne's lock.—The lower channel, which is much the more direct, is obstructed just opposite the village of St. Anne's at the head of the island of Montreal, by a succession of short rapids. The necessity of overcoming these, and relieving trade from the exactions of the owners of the private lock at Vaudreuil, was early felt, and soon after the completion of the Ottawa River and Rideau Canals, urgent representations were made to the Government that the benefits of this system was being partially lost, and a monopoly of the traffic secured to this private company who owned the lock at Vaudreuil by the want of a lock at St. Anne's.

Nothing decisive was done until 1840, when the work of constructing a lock at this point was begun by the government of Lower Canada, and after the union was carried to completion by the Government of the United Provinces. It was opened for use on the 26th of June, 1843. The canal was one-eighth mile long and the lock 190 feet long by 45 wide, with 7 feet on the sills in the ordinary state of the river and 6 feet at low water, and had a wing-dam and capacity for large steamers. It cost \$134,456.51, of which \$19,860.02 was paid by the government of Lower Canada, and the remainder by the United Provinces.

CHAMBLY CANAL.

The Richelieu or Sorel River is the channel by which the waters of Lake Champlain flow into the St. Lawrence. Its mouth is near Sorel, 46 miles below Montreal. It was navigable at all times a distance of 14 miles from Sorel to St. Ours, at the foot of the Chambly rapids. These rapids extend from St. Ours to St. John's, and were impassable both because of the shallowness of the water and the strength and ra-

pidity of the current. The company, which was chartered in 1817 to improve the navigation of this river, and to which reference has been made, went no further than to make surveys, formulate plans, and publish a report. Its rights having been forfeited by a lapse of time an act was passed in 1823, authorizing the Government to improve the navigation of the Richelieu and fixing the breadth of the locks to be constructed at 20 feet and the depth at 5 feet. After considerable delay a commissioner was appointed to take charge of the work, and the necessary surveys were proceeded with.

Various plans were proposed, and an effort was made to remove some of the most formidable obstructions by dredging, but this not producing the result hoped for, it was finally determined to raise the water to a navigable height by a dam and lock at St. Ours, and build a canal along the west side of the river from Chambly, the head of the slack-water afforded by the dam, to St. John's. Contracts were given out for the construction of the canal, and in 1835 the undertaking had so far progressed that boats could come from Lake Champlain to Chambly. During the six following years very little was done, and it was not until after the union in 1841 that the work was again taken energetically in hand, and not until 1843 that it was completed. In 1844 the location of the proposed lock and dam at St. Ours was changed. Their construction was then immediately proceeded with, and they were finished in 1849.

The work on both divisions had, however, been done so defectively that constant alterations and repairs were necessary. The walls of the lock at St. Ours and the banks of the canal were raised during the year 1851 and 1852, and in 1858 the whole system was renovated and put into thorough order, and has since been maintained in this condition.

St. Ours lock.—As thus completed the St. Ours lock was 200 feet long and 45 feet wide, with a depth of 7 feet on the sills at low water.

The dam stretched from the west shore 600 feet to an island, and thence 300 feet more to the east shore, and by means of it the water was raised 4 feet and retained so as to give a depth of not less than 7 feet from the lock to the lower entrance of the canal, a distance of 32 miles. The canal was 12 miles long, 36 feet wide at the bottom and 60 feet at the surface. There were one guard and eight lift locks, which overcame a fall of 74 feet. The guard lock was 122 feet long and 23½ feet wide, and the lift locks varied in size from 125 feet long and 23½ feet wide to 118 feet long and 23 feet wide. The depth of water on the sills was 7 feet.

As nearly as can be ascertained \$322,441.58 was paid by the government of Lower Canada on these two works, and \$433,807.83 by the Government of the United Provinces, about \$55,000 of which was for work done before the union; making a total cost up to 1867 of \$756,249.41, a part of which was for interest on loans and a part for the constant repairs which were necessary. Of the total cost \$121,537.65 was expended on the dam, and \$634,711.96 on the canal.

WELLAND CANAL.

The waters of Lake Erie empty into Lake Ontario through the Niagara River and over the Niagara Falls. The difference in the levels of the two lakes can not be stated with any exactness, as the influences which cause the variations in the height of water in the two lakes are not identical. It is, however, as nearly as can be ascertained 326½ feet.

The course of the Niagara River is almost due north, and its current is swift and turbulent.

The Welland River flows nearly at right angles with the Niagara River and discharges into it at Chippewa, a village about 2 miles above Niagara Falls. It is navigable for deeply loaded vessels a distance of 40 miles or more, and has scarcely any current. The Grand River flows southeasterly and empties into Lake Erie.

Port Maitland, one of the safest harbors on Lake Erie, is situated at the mouth of the Grand River.

Port Colborne, another very secure harbor on the same lake, is about 18 miles west of the upper end of the Niagara River. Port Dalhousie, on Lake Ontario, is about 11 miles west of the mouth of the Niagara. The desirability of connecting the two lakes by navigable water was very early in the history of the country admitted by all who gave the matter attention; surveys were made from time to time, and various plans proposed and discussed, but nothing definite was done until in 1824 a private company was incorporated under the name of the Welland Canal Company. Their first intention seems to have been to establish a line of communication between the two lakes by a combination of canal and railway, the canal to be of comparatively small capacity; but this plan was soon laid aside, and it was determined to secure water communication through the whole length and build a canal sufficiently large to admit schooners and sloops.

The plan thus adopted contemplated utilizing the Niagara River from Lake Erie to the mouth of the Welland River, the Welland River for a distance of $8\frac{1}{2}$ miles, and building a canal from Welland River to Lake Ontario. The water supply was to be obtained from the Welland River, and a high ridge of land in the line of the proposed canal was to be overcome by a deep cut. There were many objections to this plan, the chief of which were the circuitous course necessitated by the use of the Niagara and Welland Rivers, the swift current of the Niagara and its unsuitableness for heavily loaded boats, and the constant danger of slides because of the unstable character of the soil through which the deep cutting would have to be made. Notwithstanding these objections and various other obstacles which were developed by close inquiry and examination, the company adhered to their plans, and in July, 1825, entered into contract for the prosecution of the work. But the undertaking dragged from lack of funds, and frequent applications for assistance to the General Government and to the governments of Upper and Lower Canada became necessary. All these governments responded liberally both in the way of loans, subscriptions to stock, and grants of land.

In the summer of 1828 construction had made such progress that it was confidently expected that the water would be let into the canal by the autumn of that year; but just at this time the predictions of the opponents of the scheme were realized and the completion of the enterprise delayed by the falling in of a part of the embankment in the deep cut. The accident was so formidable as to seriously embarrass the company, already well drained of its resources and working on a plan not generally approved. The directors, therefore, abandoned the design of using the Welland River as a feeder, and determined to obtain their water supply for the canal from the Grand River, through a new feeder to be constructed, 27 miles long. This necessitated raising the level of the canal; but the depth of cutting was at the same time diminished $15\frac{1}{2}$ feet, and the danger of a recurrence of the accident be-

fore referred to very much lessened. Work was again begun and prosecuted with so much vigor that on November 30, 1829, two schooners ascended the canal from Lake Ontario to the Welland River.

In a report of the operations of the company published about this time the route as then established is thus described :

Vessels drawing $7\frac{1}{2}$ feet of water and not having more than $21\frac{1}{2}$ feet breadth of beam will sail down the river Niagara until they approach about one-fourth of a mile from the mouth of the Welland River. There they will enter a canal 15 chains in length which has been cut across a point of land into the Welland River, up which they will pass a distance of $9\frac{1}{2}$ miles. They will then ascend two locks into the deep cut and pass through it, a distance of $16\frac{1}{2}$ miles more, into Lake Ontario.

The feeder was 20 feet broad at bottom, 40 feet at water surface, and 5 feet deep. The success of the scheme led the Government in 1831 to grant the company a loan of \$200,000 to assist in carrying out a project for an extension of the main line over the Welland River to Port Colborne by enlarging the feeder for about 5 miles so as to make it a navigable channel, and excavating a new canal for the remaining distance between the main line as originally completed and Lake Erie.

This work was finished in 1833 and the line thus constructed occupied nearly the same site as the enlarged line of 1841 and the old line of the present day, having the same termini on the two lakes. It was $27\frac{1}{2}$ miles long and the breadth at the bottom was 24 feet. There were 40 locks, built of wood, all 110 feet long by 22 feet wide, except the first three ascending locks from Port Dalhousie, which were 130 by 32 feet, and one at Port Colborne, from the canal into Lake Erie, which was 125 by 24 feet.

At the solicitation of the company an act was passed in 1839 authorizing the purchase by the province of the rights of the private stockholders, and shortly after the union, in 1841, the purchase was made and the line was transferred to the new board of works of Canada.

Up to this time it had cost the province of Upper Canada, in loans, which were never paid, in advances, and in the purchase of stock, \$1,751,427.77, and in addition \$100,000 had been contributed to its construction in the purchase of the company's stock by the government of Lower Canada, and \$222,220 in loans by the Imperial Government, making the total cost \$2,073,647.77.

BURLINGTON BAY CANAL.

A low, sandy beach originally separated Burlington Bay, on which the city of Hamilton is situated, from Lake Ontario. The construction of a canal to connect these two bodies of water and enable vessels to reach Hamilton and the Desjardins Canal, a work belonging to a private company, and leading to the town of Dundas, was authorized by an act passed by the legislature of Upper Canada on the 19th March, 1823.

Work was commenced under local commissioners in 1825, and the canal was opened for the passage of vessels in 1830, and completed in 1832.

From 1832 to 1841 the work was gradually extended and the channel deepened. The canal was half a mile long, from 108 to 138 feet wide, and 10 feet deep, and was simply an artificial channel between two lines of wooden piles, backed with stone.

The amount expended upon this work up to the time of the union, in 1841, was \$124,306.08.

DESJARDINS CANAL.

The Desjarlins Canal above referred to does not properly belong to the canal systems of Canada, but a brief reference to it in this place may be of interest. It was built by a private company incorporated in January, 1826, by the legislature of Upper Canada, and was opened for vessels drawing $7\frac{1}{2}$ feet of water in August, 1836. It extended from a point at the head of Burlington Bay, 2 miles north of Hamilton, to the town of Dundas, and was, including natural and artificial navigation, between 3 and 4 miles in length. It cost \$98,684, and of this amount \$68,000 was advanced at different times by the government of Upper Canada in the form of loans at 6 per cent. It is perhaps needless to add that neither the principal nor interest of these loans has ever been paid.

CORNWALL CANAL.

The Cornwall Canal, which overcomes what are known as the Long Sault Rapids of the St. Lawrence, was the first canal constructed on the scale recommended by Colonel Phillpott, and adopted by the government of United Canada, for the enlargements and new works then projected.

The circumstances connected with the submission of this report and the adoption of the scheme suggested in it will be alluded to hereafter.

As far back as 1817 the attention of the government of Upper Canada had been called to the important question of the navigation below Prescott, and the joint commission appointed by the two provinces in 1818 had reported, as has been stated, in favor of improvements at the Long Sault Rapids. Examinations and reports were made by several engineers, acting under governmental authority, but nothing decisive was done until 1832, when the house of assembly of Upper Canada recommended the immediate commencement of improvements between Cornwall and the head of the Long Sault Rapids on a scale to admit vessels drawing 9 feet of water, and appropriated the sum of \$280,000 therefor.

In 1833 a commission was appointed for the purpose of carrying out the provisions of the act, in accordance with plans submitted to the Government. In 1834 the work was put under contract, but the rebellion of 1837 and financial causes retarded its completion. Work was entirely suspended in 1838, but in 1842 it was resumed by the government of the United Provinces, and the canal was formally opened in June, 1843.

The canal extended along the north shore from the town of Cornwall to the village of Dickinson's Landing, was $11\frac{1}{2}$ miles long, 100 feet in breadth at the bottom, and 150 feet at the water surface, and 9 feet in depth.

There were seven locks, overcoming a rise of 48 feet, 200 feet long and 55 feet wide, with a depth of 9 feet on the sills. Supply in regulating weirs at the head of the canal and at each of the locks were afterwards added. The whole work cost \$1,933,152.69; \$1,426,316 was expended by the government of Upper Canada and the balance by the Upper Provinces.

Towards the year 1832 the government of Lower Canada had removed some of the obstructions in these same rapids and cut a canal about one-fourth of a mile long across the point at Cedar Village, and commenced a canal intended to be two-thirds of a mile long across the point just above the old canal at Coteau du Lac. The latter canal was

cut for a distance of one-eighth of a mile, but no further work was done upon it until 1841, when a Mr. McBaine completed it by permission of the Government, building at the upper end a lock about 120 feet long, 15 feet wide, and 4 feet deep.

The government of Lower Canada expended upon the above mentioned improvements \$40,405.33. They became, of course, useless for any but local purposes upon the completion of the Cornwall Canal.

UNION OF UPPER AND LOWER CANADA.

In 1841 the provinces of Upper and Lower Canada were united under one government. Up to this time, as the foregoing statement has shown, much had been done by the respective provinces and by the Imperial Government towards removing the obstacles to a free navigation of the waterways of the country, and many local improvements, both of a permanent and temporary character, had been made, but the want of a definite and comprehensive scheme had been seriously felt. Jealousies and differences of opinion and policy had prevented a hearty coöperation between the two provinces, both in the adoption of plans and the expenditure of money.

Attempts have been made, by means of joint commissions and in other ways, to secure greater harmony and uniformity, but without much success. When, however, the long-considered project of a union of the two provinces seemed likely to be consummated, Lord Durham, then governor-general, in preparation for the event, commissioned Lieutenant-Colonel Phillpott, a prominent military engineer, to examine into and report upon "the inland water communication of the Canadas." His examination seems to have been a very minute and careful one, and his report was very elaborate. It formed the basis of the action afterwards taken by the Government of Canada in relation to the improvement of their waterways. He advocated the adoption of a uniform system of navigation improvements, and urged that they should be upon a scale commensurate with what he believed was to be the future trade of Canada. He recommended that the locks throughout the whole St. Lawrence system should be made of the same dimensions as those adopted for the Cornwall Canal, which was then under contract, to wit, with locks 200 feet in length by 55 feet in breadth, with 9 feet of water on the sills. He also proposed a new and enlarged line for the Lachine Canal, which had already become inadequate to the necessities of the growing lake commerce.

WORKS CONSTRUCTED UP TO 1841.

A statement at this point in the narrative of what works had been finished and what were in progress at the date of the union may be an aid to a proper understanding of what was still necessary to be done in order to perfect the various lines and bring them to the scale recommended by Colonel Phillpott, and, as we shall see, adopted by the Board of Works of Canada.

There had been constructed:

First. On the St. Lawrence route:

(1) The Lachine Canal, to overcome the Lachine Rapids or Sault St. Louis.

(2) The Welland Canal, to connect Lakes Ontario and Erie.

Both of these canals were proving themselves entirely insufficient for the purposes for which they were built.

(3) The Burlington Bay Canal, which was rather subsidiary to than a part of the St. Lawrence route.

(4) The Desjardins Canal, which was owned by a private corporation, although aided by a loan from the Government, and was a local affair.

Second. On the Montreal and Kingston route:

(5) The Carillon and Grenville Canals, around the rapids of Ottawa, above St. Anne's.

(6) The Rideau Canal, between Ottawa and Kingston.

(7) The River Tay Canal.

There was also, as a part of and necessary to this system, until the completion of the lock at St. Anne's, the private lock, before described, at Vaudreuil.

There were in process of construction:

On the St. Lawrence route: The Cornwall Canal, to avoid the Long Sault Rapids.

On the Ottawa: The St. Anne's lock, which was intended to supersede the private lock at Vaudreuil and complete the works of the Montreal and Kingston system.

And on the Richelieu: The St. Ours lock, which with the Chambly Canal projected, but not then commenced, was intended to overcome the Chambly Rapids and remove all obstruction to navigation between the St. Lawrence and Lake Champlain.

In addition there were two or three works at various points on the River Trent which were of local importance only.

There had been expended, or advanced upon loans which had never been repaid, for the construction of these various works as follows:

By the government of Lower Canada:

On the Lachine Canal.....	\$398,404.15
On the Chambly Canal.....	322,441.58
On the St. Anne's lock.....	19,860.02
On the Welland Canal.....	100,000.00
Total.....	840,705.75

By the government of Upper Canada:

On the Welland Canal.....	1,751,427.77
On the Cornwall Canal.....	1,448,538.37
On the Burlington Bay Canal.....	124,356.08
On the Desjardins Canal.....	68,000.00
On the River Tay Canal.....	5,630.35
On the River Trent Canal.....	92,449.33
Total.....	3,490,401.90

By the imperial government:

On the Rideau Canal.....	3,911,701.47
On the Lachine Canal.....	40,000.00
On the Welland Canal.....	222,220.00
Total.....	4,173,921.47

Total by governments..... 8,505,029.12

By private corporations:

On the Desjardins Canal.....	30,684.00
On the River Tay Canal.....	10,000.00

Grand total..... 8,545,713.12

In addition to this amount there was what the war department of the imperial government had spent on the locks between Lakes St. Louis and St. Francis, on the St. Lawrence, and on the Ottawa Canals, all record of which has been lost.

Of these routes the most important was, of course, the St. Lawrence. While the Welland Canal connected the upper lakes with the St. Lawrence, and the Lachine Canal brought both the St. Lawrence and the Ottawa systems into communication with tide-water, there were still several stretches between the two which were not at all, or very inadequately provided for. These were the rapids between Lakes St. Louis and St. Francis, and the series of rapids between Dickinson's Landing and Prescott.

The only means of passing the former were the small locks originally built by the French, and subsequently enlarged and improved by the royal staff, and the canals built by the government of Lower Canada, in 1832, across the point at Cedar Village and the point just above it. These were totally inadequate to the requirements of trade, and were of little practical use. At the latter there were no improvements at all.

Upon the union all the works completed and in progress were transferred to the board of public works.

Estimates for carrying out the scheme proposed by Colonel Phillpott were presented to the legislature, and the scheme itself, with some modifications, was adopted.

The board went energetically to work to complete the undertakings already on hand and make the enlargements and build the new works contemplated in the plan adopted, and in a few years the result of their efforts made itself evident in a canal system which was quite beyond the necessities of the hour, but which the growing trade of the country soon outstripped.

The first new work entered upon after the union was the Beauharnois Canal.

BEAUHARNOIS CANAL.

The rapids to be overcome by this canal were three in number, the Cascades, Coteau, and Cedar Rapids, and occupy 7 of the 11½ miles between the Lakes St. Louis and St. Francis, the intervening spaces being tranquil water of sufficient depth for navigation.

In 1833, Mr. Mills, the engineer of the commissioners appointed by the government of Lower Canada to "consider all matters relating to the navigation of the St. Lawrence between Cornwall and Kingston," presented three distinct schemes for the improvements in view at this point. The first of them, which he recommended as on the whole the most feasible, contemplated the construction of short canals at each of the rapids and the use of the St. Lawrence between them. These canals were to be on the north side of the river, and the descent was to be overcome by nine locks. This plan was approved by a committee of the legislature, but was never acted upon. Subsequently other plans, based upon careful investigations, were submitted to parliament by Mr. Alexander Stevenson, and Messrs. Stevenson and Baird, but they shared the same fate as that of Mr. Mills. These latter gentlemen urged the south side of the river as best adapted, both in respect to convenience of location and economy in expenditure, for the improvements suggested.

Colonel Phillpott in his general report reviewed the various plans and approved Mr. Mills's plan of three small canals, and advised that for military reasons they should be placed on the north side of the river.

In the memorandum submitted by the board of public works immediately after the union, provision was made for perfecting this section of the St. Lawrence navigation in accordance with the latter plan, and the cost was estimated at \$1,023,600.

Before anything was done, and in February, 1842, the chief engineer of the board of works reported in favor of a single canal on the south shore, chiefly on the ground that it would be shorter and independent of all water-courses, especially of the Ottawa, and consequently navigable for 2 or 3 weeks longer every season than if built on the north shore.

The relative merit of the various schemes were exhaustively discussed by their respective advocates before a committee of Parliament, and substantially the plan recommended by Mr. Stevenson, to wit, a single canal on the south side of the river and running some distance inland, was adopted. The canal was opened for navigation in the fall of 1845, but various defects were soon developed in the construction of the upper entrance, and it became necessary to build at once two dams, one 627 feet long and the other 792 feet long. The dams were completed in 1850.

The canal was $11\frac{1}{2}$ miles in length, 80 feet broad at the bottom, and 120 feet at the surface. It contained nine locks, 200 feet long and 45 feet wide, with 9 feet of water on the sills and overcoming a rise of $8\frac{1}{2}$ feet. Subsequently regulating weirs were constructed at each of the locks, and a dike about 5 miles long was built at the head of the canal to prevent flooding.

The total cost of the work up to 1867 was \$1,611,424.11, of which \$22,783.45 was expended on the dams and a considerable sum, the exact amount of which I can not give, for damages from overflow.

From the head of the Cornwall Canal there is smooth navigable water for a distance of 5 miles, then follow a series of rapid and swift currents with intervening spaces of smooth water.

WILLIAMSBURG CANALS.

The rapids are overcome by three distinct canals, known collectively as the Williamsburg Canals, and situated on the north side of the river. The construction of these canals had been recommended by the joint commission of 1818, and subsequently by Mr. Benjamin English and Colonel Phillpott, and had been the subject of much discussion in and out of the legislature.

FARRAND'S POINT CANAL.

Preliminary surveys had been made for the first or lowest of them, the Farrand Point Canal, before the Cornwall Canal was commenced, but nothing was actually done upon it until 1844, 4 years after the union, when the board of public works began its construction, and it was completed in 1847. It was three-fourths of a mile long, 50 feet broad at the bottom, and 90 feet broad at the water surface. It had one lock 200 feet long and 45 feet wide, with 9 feet of water on the sill, and overcoming a rise of 4 feet.

RAPIDE FLAT CANAL.

Although the construction of the second of the series, the Rapide Flat, to overcome the rapids of the same name, had been urged as early as 1826, work was not commenced until 1844, and it was not finished until some years later. This canal was 4 miles in length, 50 feet in width at the bottom, and 90 feet at the water surface. There were two locks, 200 feet long and 45 feet wide, with 9 feet of water on the sills, and overcoming a rise of $11\frac{1}{2}$ feet.

GALOPS CANAL.

Work on the third, viz, the Galops, to avoid the Galops and Iroquois Rapids, was commenced in 1844. The first section was completed in 1846, the second in 1847, and the whole in 1856. As originally built it consisted of two canals. The Iroquois Rapids was overcome by the first of these, 3 miles long, with one lock, 200 feet long by 45 feet wide, and of 6 feet lift. From the head of this canal the St. Lawrence was navigable for $2\frac{3}{4}$ miles to the foot of the Galops Rapids. To overcome these rapids a second canal was built, $2\frac{1}{4}$ miles long, with two locks, 200 feet long by 45 feet wide, and of 8 feet lift. After a few years' experience it was found that the first mentioned, the Iroquois Canal, had not sufficient depth of water, and it was decided to raise it by connecting it with Galops.

Work upon this junction canal was commenced in 1851 and completed in 1856.

These three canals formed, upon the completion of the junction canal, one canal, which is now called Galops Canal.

The cost of these various canals, denominated generally the Williamsburg Canals, cost \$1,320,655.54, and was paid into the treasury of the united provinces.

The channel through all these various rapids, although swift, is of sufficient depth for the safe passage of the largest boats, and the Williamsburg Canals are not used by descending crafts of any kind, unless heavily loaded, nor by ascending passenger vessels.

LACHINE CANAL—ENLARGEMENTS OF 1843.

Besides the construction of the Beauharnois and Williamsburg Canals, and the completion of the works which were partially built at the time of the union, the board of public works of the united provinces commenced in 1843 an enlargement of the Lachine Canal.

The old canal, built in 1825, had long before become utterly inadequate to the requirements of commerce.

Colonel Phillpott had proposed that the old line, the location of which had never been quite satisfactory, be abandoned and an entirely new canal constructed on a better line, and this plan had many advocates. It was found, however, that it would be very expensive, and as the advantages to be gained by its adoption were at the best questionable, it was decided to retain the old location and increase the capacity of the locks and the width and depth of the canal prism, so as to make them equal to those of the Cornwall and Beauharnois Canals.

During the progress of the work and the urgent request of the mercantile interests, this plan was so far modified as to increase the depth of locks Nos. 1 and 2 at Montreal from 9 feet to 16 feet of water on the sills, and thus enable the largest sea-going vessels which then visited Montreal to pass easily into the first basin of the canal.

The work was sufficiently advanced in 1848 to permit passage of boats, but as some of the cuttings were through Silurian lime the canal was not excavated to its full width in all places until 1862.

The enlarged canal was of the same length as before, $8\frac{1}{2}$ miles, and 80 feet wide at the bottom and 120 feet at the water surface; it contained five locks, 200 feet long and 45 feet wide, with a depth of 9 feet of water on the sills, except locks Nos. 1 and 2, which had a depth of 16 feet in accordance with the modification of the original plan just adverted to.

The capacity of the canal was more than doubled by these improvements and the number of locks reduced from seven to five.

The enlargement cost \$2,149,128.70 and was of course paid for by the Government of United Canada.

WELLAND CANAL IMPROVEMENT OF 1842-'49.

The Welland Canal as originally built had never been satisfactory either in its location, its dimensions, or in the character of the work, and it had never been looked upon as permanently completed.

From time to time surveys and investigations had been made and changes and improvements suggested, but nothing of any moment had been done.

As soon, however, as the line came wholly under the control of the government by the purchase of the interests of the private holders, it was determined by the board of public works to commence improvements.

It was decided that all the locks should be rebuilt in stone and their dimensions increased to 120 feet long by 26 feet broad, with 8½ feet water on the sills; that the aqueduct required to carry the canal over the Welland River should be rebuilt of stone; that the feeder should be converted into a navigable canal; that the harbors on both lakes should be improved, and finally that the projected Port Maitland Branch should be undertaken and completed with an entrance lock from Lake Erie 200 feet long, 45 feet wide, and having 9 feet depth of water.

The works were commenced in 1842 and completed in 1849.

The original plan was modified during the progress of the work so as to make the locks 150 feet long by 26½ feet wide, and the bed of the main line 26 feet wide at the bottom.

As the Grand River gave evident signs that it could not be relied upon as a feeder, it was decided to obtain the water supply for the canal from Lake Erie. To do this it became necessary to lower the summit level 8 feet to that of Lake Erie.

This undertaking was commenced in 1846, but was not finally completed, so as to render the canal independent of the Grand River until a few years ago.

These enlargements and improvements cost the government of Canada up to 1st July, 1867, \$4,900,820.60.

TRENT RIVER AND NEWCASTLE DISTRICT NAVIGATION.

The Trent River and Newcastle district navigation in its present condition does not, in either section of it, form a completed system, but consists simply of local improvements which have been made from time to time and at various points between Trenton, on the Bay of Quinté, into which the Trent River empties, and Lake Simcoe, a large body of water north of Toronto, and about half way on a direct line between Lake Ontario and Georgian Bay.

These improvements are of two kinds, viz, those to render the channel navigable for vessels, and those to facilitate the passage of lumber.

Those of the former kind are situated between the mouth of the river Trent and the town of Lindsay on the Scugog River, and between Lindsay and Port Perry, at the head of Lake Scugog.

The total distance between the Bay of Quinté, at the mouth of the

river Trent, and Port Perry is 161½ miles, of which 34½ miles are not navigable for vessels drawing 5 feet of water.

The following is a list of the works which have been or are being constructed.

CANAL AT CHISHOLM RAPIDS.

At what is known as the Chisholm Rapids, 15 miles above Trenton, is a fall of something more than 8 feet, and here in 1873 a canal 2,927 feet long was cut through bedded limestone, and a dam built to make still-water navigation for the remainder of the distance covered by the rapids.

The canal had one lock of dressed masonry, 133 feet 2 inches long, and 33 feet wide.

CANAL AT LAKE BOBCAYGEON.

Between 1833 and 1835 a short canal, with a wooden lock, was constructed at Lake Bobcaygeon 140½ miles above Trenton. By this canal (which is still maintained, a stone lock having been substituted for the wooden one in 1857) vessels drawing not more than 4 feet are enabled to pass from lakes Chemong, Buckhorn, and Pigeon to Sturgeon Lake and thence up the Scugog River to the town of Lindsay, which is connected with Lake Ontario by railroad.

A similar lock was built at Lindsay in 1844 and was subsequently converted into a timber slide.

Hasting's Lock.—In 1844 a lock, now known as Hasting's Lock, and a dam was completed at Crook's Rapids, a point 32½ miles above the mouth of the Trent River. By this lock navigation is obtained from Huley's Falls to Whitla's, a distance of 60½ miles, and during the same year a dam was built at Nine-Mile Rapids.

Lock at Whitla's.—In 1843 a lock was constructed at Whitla's, 93 miles above the mouth of the Trent, by means of which vessels may ascend to Peterborough, a thriving town one-half mile above Whitla's.

Upon these works there was expended by the government of Upper Canada, before the union, \$93,549.33; and by the government of United Canada, up to 1867, the date of confederation, \$216,921.98.

In 1870 the lock at Lindsay, which had been converted into a slide, was rebuilt by the government of the province of Ontario. Its dimensions are 134 feet by 34 feet wide, with 5 feet of water on the sills.

In the fall of 1882 work was commenced at various points along what is known as the Black Lake division, which extends from Lakefield to Balsam Lake, the summit level on the main line of the Trent River navigation, and satisfactory progress has been made. At the Upper Rapids, between Deer Bay and Buckhorn Lake, a lift lock and small canal one-fourth mile long are being built.

At the falls between Sturgeon and Cameron Lakes, a canal about one-third of a mile in length with two lift locks is under contract.

The contract for the former of these routes requires that it shall be completed this year, and for the latter that it shall be completed next year.

Contracts have been given out for the construction of a canal 2½ miles long, with three lift locks and regulating dams, around the Burleigh and Lovesick Rapids, but operations have not yet been commenced.

These locks and the service works are to be 134 feet long, 33 feet wide, and have a depth of 5 feet on the sills. When they are all completed, these improvements will open up about 150 miles of direct and lateral navigation.

CONFEDERATION.

On the 1st of July, 1867, the province of Canada, composed of the old provinces of Upper and Lower Canada, now known respectively as Ontario and Quebec, and the provinces of Nova Scotia and New Brunswick were consolidated under one government and constituted the Dominion of Canada.

The public works of each province became the property of the Dominion and were placed under the control of its commissioner of public works.

EXPENDITURES PREVIOUS TO CONFEDERATION.

Up to this time, according to the official reports, there had been spent upon the canals and works connected with them about \$22,000,000, distributed as shown on the annexed schedule:

Manner of expenditure.	Before the union.	During the union.	Total cost to June 30, 1867.
Lachine Canal.....	\$438,404.15	\$2,149,128.70	\$2,587,532.85
Beauharnois Canal.....		1,611,424.11	1,611,424.11
Cornwall Canal.....	1,448,538.37	484,614.32	1,933,152.69
Williamsburg Canal.....		1,320,655.54	1,320,655.54
General expenditure.....		116,821.31	116,821.31
Burlington Bay Canal.....	124,356.08	308,328.32	432,684.40
Desjardin Bay Canal.....	98,684.00	52,263.93	150,947.93
St. Lawrence system.....	2,109,982.60	6,043,236.23	8,153,218.83
Welland.....	2,073,647.77	5,564,592.06	7,638,239.83
St. Ann's lock.....	19,860.02	114,596.49	134,456.51
Chute à Blondeau Canal.....		63,053.64	63,053.64
Rideau Canal.....	3,911,701.47	153,062.60	4,064,764.07
River Tay navigation.....	15,680.35	2,133.70	17,764.05
Montreal and Kingston system.....	3,947,191.84	332,846.43	4,280,038.27
Chate (Upper Ottawa).....		482,950.81	482,950.81
St. Ours lock and dam.....		121,537.65	121,537.65
Chambly Canal.....	322,441.58	812,270.18	634,711.76
Richelieu and Lake Champlain system.....	322,441.58	433,807.83	756,249.41
River Trent navigation.....	92,449.33	216,921.98	309,371.31
Total expenditure.....	8,545,713.12	13,074,355.34	21,620,068.46

Of this amount \$3,490,401.90 has been paid by the province of Upper Canada; \$840,705.75 by the province of Lower Canada; \$4,173,921.47 by the Imperial Government; \$13,074,355.34 by the United Provinces, and \$40,684 by private corporations.

In addition to this were, as before noted, the expenditure by the Imperial Government in the renovation and enlargement of the old locks and canals, between lakes St. Louis and St. Francis, and the construction of the three Ottawa River or "Ordnance Canals," and also \$48,405.83 spent by the government of Lower Canada in attempting to improve the channel through the Lachine Coteau and Cedar Rapids.

As a result of this expenditure, aggregating nearly \$22,000,000, there came into possession of the Dominion, as part of the assets of United Canada, transferred under the provisions of the act of confederation, 248½ miles of canal with 142 locks; of which, 205½ miles of canal and 100 locks were in Upper Canada, and 43 miles of canal and 42 locks were in Lower Canada.

The St. Lawrence system, including the Welland and Burlington, comprised 94.08 miles of canal and 57 locks, the least depth of which was 9 feet on the miter sills.

The Montreal and Kingston system, including the river Tay navigation, comprised 134.39 miles of canal and 64 locks, the least depth of which was 5 feet on the miter sills.

The total lockage in this system going from Montreal to Kingston was 578½ feet—401½ feet rising and 177 feet falling.

The Richelieu and Lake Champlain system comprised 12.13 miles of canal and 10 locks, the least depth of which was 7 feet on the miter sills.

For some years after the completion of the works above described very little was done beyond what was necessary to keep them in repair.

APPOINTMENT OF CANAL COMMISSION.

In 1870 the Governor-General of the Dominion appointed a commission, of which the late Sir Hugh Allen was chairman, "to make inquiry as to the best means of securing a thorough and comprehensive improvement of the canal system, and to collect reliable information upon which to base a plan therefor."

REPORT OF CANAL COMMISSION.

The commission, after a careful and searching inquiry, submitted an elaborate report. In this report they discussed quite exhaustively the commercial and engineering aspects of the questions submitted to them, detailed the result of their investigations under each head, and made certain recommendations, of which the following is an abstract:

1. That one uniform size of locks and canals be established throughout the whole of the St. Lawrence route, including the St. Lawrence canals proper, the Welland Canal, and the proposed Sault Ste. Marie Canal.

That the locks be made 270 long and 45 feet wide, with a depth of 12 feet clear on the miter sills, and that the bottom of the canals be sunk at least 1 foot below the miter sills of the locks, with a width throughout of not less than 100 feet. They stated that these dimensions would enable vessels of the usual build, carrying 1,000 tons, to pass, and if their breadth of beam and sectional areas were increased the canals might be navigable for vessels of 1,500 tons.

In giving their reasons for fixing the greatest depth of water on this route at 12 feet, the commission say:

While some of the writers who ought to be best informed on the subject recommend a draft of 14 feet and others as much as 16 feet, regard must nevertheless be had to the capabilities of the harbors and the engineering characteristics of our canals, as well as the prudent suggestions of moderate and experienced men who have limited their views to 12 feet. It would be extremely unwise to embark in magnificent schemes, exceeding the resources of a young country, with the view of introducing ocean vessels into our canals and lakes.

2. That the locks on the proposed Bay Verte Canal be made 270 feet long and 50 feet wide, with a depth of 15 feet on the miter sills.

3. That the locks in the Ottawa system be made 200 feet long, 45 feet wide, with a depth of 9 feet on the miter sills.

4. And that the locks in the Richelieu River be also made 200 feet long and 45 feet wide, with such a depth on the miter sills, not exceeding 9 feet, as the channel of the Richelieu would afford.

The dimensions fixed upon for these routes were thought sufficiently large to accommodate the largest barges used for carrying lumber, that being the main article transported through them.

IMPROVEMENTS RECOMMENDED.

They grouped the improvements recommended, according to their importance, into three classes, and recommended that they be taken up and pushed to completion in the order named, and with as much rapidity as circumstances and the funds at the disposal of the Government would permit.

In the first class they put:

1. The construction of the proposed Sault Ste. Marie Canal.
2. The enlargement of the Welland Canal.
3. The improvement of the Ottawa and Chambly Canals.
4. The deepening of the navigable channel of the St. Lawrence below Montreal to an average depth of 22 feet.
5. The construction of the proposed Bay Verte Canal.
6. The enlargement of the St. Lawrence canals and the construction of new locks and docks at the lower entrance of the Lachine Canal.
7. The improvement of the channel of the St. Lawrence above Montreal by removing all obstructions in the river and lakes between the several canals, and also at the ingress and egress of these canals, so as to give 14 feet of water throughout.

In commenting upon the above-mentioned works the report says:

We considered these works of so great importance, so essential to the welfare and prosperity of the whole country that we feel some degree of embarrassment in recommending which of them should be first proceeded with, but we respectfully suggest that they should be undertaken in the order in which they are mentioned, or as far as possible simultaneously.

They put in the second class:

8. The construction of canals on the Upper Ottawa after further examination should more clearly indicate the proper method and probable cost of such improvements.

9. The improvement of the rapids of the St. Lawrence so as to secure a channel through them of at least 8 feet; and,

10. The construction of the Murray Canal, which they speak of as a work of local importance only, should be deferred until the future.

In the third class they put:

11. The construction of what is known as the proposed Caughnawaga Canal to connect the St. Lawrence by a short route with Lake Champlain.

12. The construction of the proposed Erie and Ontario ship-canals.

They state that the construction of the proposed Caughnawaga and Erie, and Ontario ship-canals should be left to the private companies which have been chartered for the purpose, and decline to advise any expenditure of the public resources therefor.

13. The construction of the Georgian Bay Canal.

In regard to the Rideau Canal they advised that some new dams and regulating weirs be built to insure a constant supply of water, but that in other respects nothing be done beyond maintaining it in good working order, it being in their estimation sufficient for the wants of the traffic for which it is the channel.

It was estimated by the commission that the improvements included in the first class, and which they looked upon as the really essential ones, would cost \$19,170,000.

The recommendations contained in this report were adopted by the government, and on the basis of the scale of navigation therein fixed for the St. Lawrence route, viz, an available depth of 12 feet of water, the necessary surveys and examinations were made and schemes for

the proposed improvements on that route were submitted, and in 1873 authority was given to the government to carry them out.

In 1875 and after some progress had been made in construction, such representations were made to the government by public bodies and business men that an order was issued to have the foundations of all permanent parts of the works not then under contract placed at a depth corresponding to 14 feet of water on the miter sills of the locks. Every year since this enlargement scheme, as it is called, was adopted the government has appropriated liberally towards carrying it out, and the enterprise has been vigorously pushed forward.

LACHINE CANAL IMPROVEMENTS.

The improvements projected for the Lachine Canal have been completed, with the exception of the entrance channel and harbor at Lachine.

The canal channel has been enlarged to a mean breadth of 150 feet and a depth of 12 feet, and new locks of increased capacity have been constructed alongside the old ones. The canal now consists of one channel with two distinct systems of locks, the old and the enlarged, both of which are in use.

The canal is protected on either side and throughout its entire length by a stone wall built in a substantial manner, and all permanent structures, including the locks, are so placed that the prism may be deepened to 15 feet without disturbing them.

There are in the old system five locks, the dimensions of which have been given in a former part of this report.

In the enlarged system there are also five locks, 270 feet in length and 45 feet in width. The depth of water on the sills of the two locks at Montreal is 18 feet, and of the three remaining locks, to wit, at St. Gabriel, Cote St. Paul, and Lachine, 14 feet respectively.

There are two deep basins situated at the lower Montreal end.

In basin No. 1, between the two lower locks (Nos. 1 and 2) and basin No. 2, or Wellington Basin, above lock No. 2, the depth, for a width of 100 feet, is 19 feet, and for the remainder is 13 feet.

Two new masonry-faced basins are in process of construction at St. Gabriel.

The completion of the entrance channel and harbor at Lachine is the principal work remaining to be done, and it is expected these will be finished early in the summer of the present year.

These enlargements have cost up to June 1882, \$5,347,414.66, making a total spent on the Lachine Canal for construction purposes, from first to last, of \$8,166,696.75.

Sea-going vessels, steam and sailing, can now pass up the canal from the harbor through locks Nos. 1 and 2 to basin No. 1 and Wellington Basin, with coal, sugar, and plaster for the different factories in this part of the city and for the Grand Trunk works, and a saving to purchasers of 20 to 35 cents per ton is effected. They can also reload at the same points, where there is ample dock room.

The current has been so much reduced that vessels drawing 8 feet can now be towed up by two pairs of horses, while six to eight pairs used to be necessary.

At locks Nos. 1 and 2 the time occupied in locking is from 12 to 14 minutes, and at Nos. 3 and 4 from 9 to 11 minutes, the difference in time being caused by the difference in lift, the lift in 1 and 2 being 5 feet more than that in 3 and 4.

Steamers pass through the whole canal in about $2\frac{1}{2}$ hours, while barges towed by steam-tugs occupy 3 hours, and those towed by horses 4 to 5 hours. Tugs are, however, fast taking the place of horses for towing purposes, except at the locks, where horses have to be used.

CORNWALL CANAL IMPROVEMENTS.

The improvement on the Cornwall Canal was commenced in 1876, and is now progressing.

A new outlet or lower entrance channel has been formed 300 feet south of the old one and extending back 3,800 feet until it joins the original canal, and two new locks taking the place of those on the old line 270 feet long by 45 feet wide, and with a depth of 14 feet on the miter sills, and a basin 825 feet long between these two locks have been constructed. The deepening of the canal so as to admit vessels of 14 feet draft, and the enlargement of the four locks near the upper entrance are contemplated, and will complete the projected improvements.

There has been spent on these improvements up to June 30, 1882, \$545,309.57, making the total outlay on this canal \$2,522,519.81.

PRESENT CONDITION OF BEAUHARNOIS AND WILLIAMSBURG CANALS.

Nothing has yet been done to carry out the recommendations of the commission in regard to the remaining canals on the St. Lawrence, viz, the Beauharnois and the Williamsburg Canals, and they remain of the same dimensions as they were originally completed, to wit, 9 feet depth of water on the miter sills of the locks; and they determine the size and capacity of the vessels to which the St. Lawrence route is in its whole length available.

Steps are to be taken towards their enlargement in conformity with the proportions of the general scheme.

GALOPS RAPIDS IMPROVEMENTS.

It is intended to improve the channel through the Galops Rapids, the shallowest of the three rapids, which are now overcome by the Galops Canal. The average depth of the natural channel at low water is 15 feet, but in some places the ledge is elevated from 3 to 4 feet above the general level, and these projections have to be removed.

The plan is to construct a straight channel 3,300 feet long, 200 feet wide, and of such depth as to afford passage at low water of vessels drawing 14 feet.

The accomplishment of this object, to quote the words of the chief engineer of canals, assumes greater importance when the fact is borne in mind that at ordinary water vessels can pass down the river from the head of the Galops Rapids to Dickinson's Landing, a distance of $32\frac{3}{4}$ miles, in less than one-third the time required to pass through the Williamsburg Canal.

Owing to the rapidity of the current great difficulty was experienced in taking the soundings and making the observations necessary to determine just what and where the obstructions were, and a specially constructed steamer had to be used for the purpose.

The desired information was finally obtained, a plan formulated, and the work was commenced in 1880.

Sufficient progress has been made to demonstrate the practicability of the undertaking and to secure its speedy completion.

When these improvements are finished, not only passenger and light-draft vessels, but the largest and heaviest laden craft will be able to use the channel of the river and avoid the Williamsburg Canal on the downward passage.

MURRAY BAY CANAL.

The peninsula called Prince Edward lies at the lower extremity of Lake Ontario and is connected with the main shore by a strip of land only 2 miles broad, on one side of which is the Bay of Quinté, and on the other Waller's Bay.

Vessels going east or west on the lake are obliged to strike out into open water in order to double Long Point, the extremity of this peninsula.

As early as 1796 the attention of the Government was directed to the great benefits to be derived from a canal through this narrow strip, by which the distance and the danger of the passage from Lake Erie to the St. Lawrence would be very much lessened.

In 1833 a survey was made under direction of the Government of Upper Canada. Two routes were suggested, one directly across the isthmus at its narrowest point, and the other from Presque Isle Harbor, one of the best natural harbors on Lake Ontario, to the head of the Bay of Quinté.

By the former route, which the engineers recommended as, on the whole, the best, it was estimated that the canal would be 2 miles long, and, if adapted to the passage of vessels drawing 8 feet of water, would cost \$171,382.50.

Colonel Phillpott, in his general report, considered both routes and estimated the cost of a canal 10 feet deep and of dimensions sufficient for the largest vessels, directly across the isthmus at \$243,333.33, and on the line from Presque Isle at \$438,000.

Again, in 1845, the Department of Public Works caused a survey to be made of the Presque Isle route, and estimated the cost of a canal 100 feet wide at the bottom and 10 feet deep at \$507,445.37. Since that time the project has been frequently before the public and warmly advocated.

The canal commission pronounced it a work entirely of local importance and not required by the general trade of the Dominion, and recommended that its consideration be deferred.

But the advantages to be derived from it seemed so clear, and the pressure for its construction was so great that, in 1881, Parliament authorized the Government to undertake the work.

After more thorough surveys and carefully testing the alleged advantages of the various projected lines, a route making Presque Isle Harbor the terminus on the lake was selected, contracts were awarded, and the work of construction began in August, 1882. By this canal, which will be about 6 miles long, the open lake navigation will be reduced at least one-half, and a great impetus it is predicted will be given to the coasting trade along the north shore of the lake.

The works consist of a through cutting of $4\frac{1}{2}$ miles in length across the isthmus of Murray and submarine excavations at the two entrances.

The channel is to be without locks, 80 feet wide at the bottom, and with a depth of 11 feet below the lowest known level of Lake Ontario.

The contracts call for the completion of the undertaking in 1885.

WELLAND CANAL IMPROVEMENTS.

The Welland Canal, as stated in the report of the canal commission, is the link between the upper lakes and Lake Ontario and the most important section of artificial navigation on the St. Lawrence route.

Its enlargement was recommended as the first and paramount step in the scheme of permanent improvements to the canal system of the Dominion.

In accordance with a plan submitted by the chief engineer of the department of public works, and in pursuance of the recommendations of the canal commission, work was commenced in 1873.

The plan provided for utilizing the existing canal, which extended, as has been mentioned before, from Port Dalhousie to Port Colborne, but it was soon found that, however advisable such a course might be on the score of economy, the requirements of the enlarged scale of navigation would not permit its being pursued between St. Catherine and the town of Thorold, and besides that a channel better for navigation purposes and less expensive to maintain could be made between Thorold and Allanburg.

These facts led to the decision to form an entirely new canal to the eastward of the old one extending from Port Dalhousie to Allanburg, a distance of 11.83 miles, then to enlarge and deepen the old canal from Allanburg to Port Colborne, a distance of 14.94 miles, and these improvements have been carried on accordingly.

The improvements are completed except the new aqueduct, which is being built over the Chippewa River, and some rock cutting between Humberstone and Port Colborne.

Between Port Dalhousie and Allanburg there are therefore two distinct routes, the old and the new, but from Allanburg to Port Colborne there is only one channel, the old canal having been enlarged, as before described.

There is one entrance from Lake Ontario, to wit, at Port Dalhousie, two from Lake Erie, one for the main line at Port Colborne, and one for the feeder route at Port Maitland, and also an entrance from the Niagara River at the town of Chippewa.

The main line of the canal, as improved and now existing, extends from Port Dalhousie to Port Colborne, 26½ miles, is 13 feet deep, 100 feet wide at the bottom, and 152 feet at the surface. It has one guard and twenty-five lift locks 270 feet long and 45 feet wide.

After considerable progress had been made in the work the plan adopted was modified so as to increase the navigable depth of the canal to 14 feet. At the time this was done a few of the locks had been constructed, and these have a depth of only 12 feet on the miter sills, while the rest have a depth of 14 feet. The shallow locks are, however, situated in that part of the line in which the water level can be raised so as to give the 2 additional feet if occasion requires.

The lock gates are opened by water wheels, and the locks can be emptied or filled in from 8 to 10 minutes.

The banks of the canal are faced with stone and trees have been planted on both sides, and it is expected that the trees will in a few years prove a great protection to vessels which are now not infrequently compelled by wind storms to tie up.

For the whole distance from Port Dalhousie to Thorold the canal is lighted by gas and a system of semaphore signals has been established.

Passage is afforded at all stages of the lake level to vessels drawing

12 feet of water, except at the point where the canal crosses the Chipewewa River. At this point it is not safe for vessels drawing more than $11\frac{1}{2}$ feet to attempt to pass. This will be remedied by the completion of the new aqueduct, which is now being built, and a uniform depth of 12 feet at least secured throughout the whole length of the main channel. Extensive repairs and renewals have been made in the old canal, and it is the intention to maintain it in good condition. The amount of business done upon it is very considerable, it being used by returning tugs, which in the busy season can get through it more rapidly. The several branches are unchanged. The improvements have cost up to June 30, 1882, \$12,498,107.36, making a total of \$20,328,728.08 spent upon this canal for construction since its inception in 1824.

BURLINGTON BAY CANAL.

The Burlington Bay Canal remains substantially as it was in 1832, when first constructed.

As has been stated before, the canal commission recommended the improvement of the Ottawa River and Richelieu River works so as to secure a uniform system from Ottawa to Lake Champlain upon a scale permitting the passage of vessels drawing 9 feet of water.

ST. ANNE'S LOCK IMPROVEMENTS.

In 1873 a new lock was commenced at St. Anne's, 200 feet long and 45 feet wide, with 9 feet of water on the sills. The masonry of the lock has been completed, and it was brought into use in August, 1882. Approach channels 100 feet wide at the bottom and of such a depth as to give 10 feet of water at the lowest known level of the river are being constructed. These improvements have cost up to June 30, 1882, \$402,847.69.

GRENVILLE CANAL IMPROVEMENTS.

The enlargement of the Grenville Canals was entered upon a year earlier, and comprised the construction of five locks 200 feet long and 45 feet wide, with 9 feet of water on the sills. The locks have been completed, but the two at the lower entrance, which are to take the place of four old ones, can not be brought into full use until further improvements are made in the channel. When these are finished, which will be during the current year, the dimensions of the channel will have been increased to a depth of 10 feet and a mean width of 40 feet at the bottom and from 50 to 80 feet at the surface, and crossing basins constructed at approximate distances of half a mile. The cost to June 30, 1882, was \$1,773,586.22.

CARILLON CANAL IMPROVEMENTS.

The improvements on the Carillon Canal were commenced at about the same time as and in connection with those on the Grenville. They comprised a dam 800 feet in length across the Ottawa River three-fourths of a mile above the village of Carillon, a slide with booms 600 feet in length, a floored channel 25 feet wide, and guide piers, a canal three-fourths of a mile long, with two locks 200 feet by 45 feet, with 9 feet of water on the sills.

The dam and slide were completed in November, 1881, and the canal

and locks in May, 1882. They cost: dam and slide, \$382,170.71; canal and locks, \$592,971.83; total, \$975,142.54.

By the construction of the dam the water has been raised 9 feet at that point and as far back as the foot of the Grenville Canal, a distance of 7 miles, the level of the river has been raised so that the depth of water on the lower sills of the entrance locks of that canal has been increased 2 feet. It was expected that the necessity of using the Chute à Blondeau Canal, lying between the Carillon and Grenville Canals, would have been obviated by this new route, but when the water is high many steamers are unable to stem the current which yet exists at the chute, and have to use the canal. It is in a bad state of repair, and its reconstruction and renovation are contemplated.

RIDEAU CANAL—PRESENT CONDITION.

The commission, it will be remembered, advised that nothing be done with the Rideau Canal beyond keeping it in good working condition. This recommendation has been followed, and no new works have been constructed nor improvements made, except that the canal basin at Ottawa has been enlarged and some dams rebuilt, increasing the facilities for obtaining water.

UPPER OTTAWA NAVIGATION.

The Chaudiere Falls, opposite the city of Ottawa, form the barrier which limits the extent of navigation on the Ottawa to vessels from Montreal and Kingston. Above this point, and as far as the mouth of the Mattawan, a distance of 192 miles, there are large stretches of navigable water, separated by rapids and obstructions to navigation. The improvement of this part of the river, both for the purpose of connecting it with the Montreal and Kingston system, and as a part of a projected line between the St. Lawrence at Montreal and the foot of Lake Huron, has been for many years the subject of earnest consideration by the Canadian authorities.

Various surveys have been made and plans proposed, but very little has been actually done towards accomplishing any definite results.

CHATS CANAL.

In 1854 an attempt was made to build a canal around the Chats Rapids, some distance above Ottawa, and \$482,950.81 were expended by the Government of Upper Canada for the purpose. The design was to make the locks 190 feet long and 45 feet wide, and adapt the whole route to a 7-foot navigation.

After the excavation of pits for several locks, and some work on the channel of the canal, it was found that the cutting would have to be for some distance through silurian rock, and therefore very expensive, and the undertaking was abandoned.

CULBUTE CANAL.

Between 1873 and 1876 the Dominion of Government constructed a small canal, known as the Culbute Canal, around the Culbute and Islet Rapids, 108 miles above Ottawa. The canal is one-eighth of a mile long, and has 2 locks, built of wood, 200 feet long and 45 feet wide, with a depth of 6 feet of water on the sills. It is supplemented by a

dam 223 feet long and 2 submerged dams, all made of wood, by which the water is raised and a 7-foot navigation secured between the head of Grand Calumet Falls and the foot of the Joachim Falls, a distance of 77 miles. The works cost \$313,412.81.

RÉSUMÉ OF WORKS COMPLETE.

The following statement shows in brief the works heretofore described, with the cost of each up to June 30, 1882.

Statement of works and cost up to June 30, 1882.

Works.	Before confederation.	Since confederation.	Total cost to June 30, 1882.
Lachine Canal	\$2,587,532.85	\$5,579,163.90	\$8,166,696.75
Beauharnois Canal	1,811,424.11	68,754.40	*1,880,178.51
Cornwall Canal	1,433,152.69	589,387.12	2,022,539.81
Williamsburgh Canal	1,320,655.54	1,077.00	1,321,732.54
General expenditures	116,821.31	237,889.33	354,720.64
Burlington Bay Canal	432,684.40	30,426.89	463,111.29
Desjardins Bay Canal	150,947.93	.....	150,947.93
St. Lawrence system	8,153,218.83	6,506,688.64	14,659,907.47
Welland system	7,638,239.83	12,690,488.25	20,328,728.08
St. Anne's lock	134,456.61	404,787.15	539,243.66
Ottawa Canal	63,053.64	2,822,800.28	2,885,853.92
Rideau Canal	4,064,761.07	67,402.19	4,132,166.26
River Tay navigation	17,764.05	.....	17,764.05
Montreal and Kingston system	4,280,038.27	3,294,989.62	7,575,027.89
Chate	482,950.81	.....	482,950.81
Culbute .....	.....	313,412.81	313,412.81
Upper Ottawa	482,950.81	313,412.81	796,363.62
St. Ours lock and dam	121,537.65	.....	121,537.65
Chambly Canal	634,711.76	42,606.64	677,318.42
Richelieu and Lake Champlain	756,249.41	42,606.64	798,856.07
River Trent navigation	309,371.31	6,398.01	315,769.32
Grand total	21,620,068.46	22,864,583.99	44,474,652.45

Of this grand total a little less than half was expended before confederation and the balance has been expended since.

PROJECTED WORKS.

There remains to be referred to what are known in official reports and pamphlets as "projected works."

OTTAWA SHIP CANAL.

Ottawa Ship-canal.—Probably the most important of these is the Ottawa ship canal, to which reference was made under the head of upper Ottawa navigation, viz, a line from Montreal to Lake Huron by way of the Ottawa and French Rivers.

These rivers formed the old French route from Quebec and Montreal to the far west, and its course may be thus traced. The Ottawa was entered at St. Anne's, just above Montreal, and ascended as far as the mouth of the river Mattawan, 305 miles above Montreal, and 192 miles above the city of Ottawa. The Mattawan was followed up its course almost due west 44½ miles to the upper end of what is known as Trout Lake, which lies at the summit level. There a low sandy ridge or

portage three-fourths of a mile wide was crossed to the northeast shore of Lake Nipissing, and the lake was traversed about half its length, a distance of 30 miles, to the headwaters of one of the tributaries of the French River. The course of this tributary and of the French River was followed for 50 miles to the mouth of the latter, at the east side of Georgian Bay, which is the northeastern end of Lake Huron.

This line of navigation has been examined several times by competent engineers under the direction of the department of public works of Canada. Their reports developed the fact that the total distance by this route from Montreal to Lake Huron, and through it to Chicago, is very much shorter than (some claiming that it is not more than half as long as) by the St. Lawrence and lakes, and it was stated that all obstructions to navigation could be overcome by the construction of a series of short canals, the aggregate length of which, including the Lachine and Ottawa Canals, would be 58 miles, and the aggregate lockage 698 feet, or, if dams were used at various points to deepen the waters in certain rapids so as to make them navigable and additional locks constructed, the total length of the canal might be reduced to 29½ miles instead of 58, although the lockage would be greater by a little over 10 feet; both plans contemplated at least 10 feet draft.

The cost of the first plan was estimated at \$24,000,000, and of the latter at \$12,057,680. It was further claimed that by damming the mouth of Lake Nipissing, at the head of French River, so as to raise the surface of its waters about 23 feet above its natural level, it would form a reservoir which would be more than sufficient to insure a constant supply of water on the summit reach. The chief physical obstacles to carrying out the undertaking were said to be that the cutting on the upper section of the Ottawa and French Rivers would have to be through Laurentian and Silurian rock.

The mouth of French River forms a safe and commodious harbor. It is also claimed that this route would be open within a fortnight, at the most, as long as the St. Lawrence.

Of the feasibility of the undertaking I am not able to judge, but the fact that, with all the energy that Canada has shown in the matter of her water communications and the frequency with which the enterprise has been before parliament, no steps have been taken to put the magnificent project into execution would seem to indicate that the judgment of the majority is against it. Of this project the canal commission say: "The importance of this work to the whole Dominion can not well, prospectively, be overestimated," but in view of the wide discrepancy in the estimates, they recommended further examination at as early a day as possible.

Trent River navigation.—Another projected line is that which comprehends as a part of it the Trent River and Newcastle district navigation, of which I have spoken before, and is intended to shorten the distance by water between Lakes Ontario and Huron. The route, as a whole, and in its various sections, has been repeatedly surveyed, and as late as 1880 a new survey of the whole route was authorized.

This survey, which is now in progress, is designed to be very complete and reliable, and to determine definitely the feasibility of constructing the line. The plan has been to improve the Trent River to Rice Lake, secure a navigable channel through a series of connected lakes until the summit level between Lakes Ontario and Huron is reached at Lake Balsam, 589½ feet above Lake Ontario, thence descend 118½ feet by a canal and the Talbot River to Lake Simcoe, and 124½ feet more by the river Severn to Georgian Bay.

This line would be extremely crooked, but it is claimed would be so much more direct than the established route, that 218 miles would be saved between Kingston, at the foot of Lake Ontario, and the Straits of Mackinac, the point of junction of the three upper lakes.

The improvements which have been made in the navigation of the Trent River, and those which are now being made, are described under the head of "Trent River navigation."

In making them, the department of railways and canals say :

Points have been selected which will enable them to afford the greatest immediate advantage to local navigation, while at the same time they would form an integral part of the best practicable line of through communication.

Toronto and Georgian Bay Canal.—Another scheme, which has had some earnest and sanguine advocates, especially in the province of Ontario, is what is known as the Toronto and Georgian Bay Canal, to connect Hunter Bay, on Lake Ontario, with Georgian Bay, by way of Lake Simcoe, and shorten the distance between Chicago and Toronto.

Caughnawaga Canal.—A favorite project, and one which at times has seemed to be on the point of adoption by the authorities, and is now by no means abandoned, is the so-called Caughnawaga Canal, to connect the St. Lawrence above Montreal with Lake Champlain. This scheme has been investigated and reported upon by many prominent engineers, who have studied it both on behalf of private promoters or under the direction of the government; all of them, I think, have declared it practicable from an engineering and desirable from a commercial point of view, and most of them have recommended that the route should be run from Caughnawaga, an Indian village just opposite Lachine, on the south side of the St. Lawrence, to St. John's on the Richelieu River, and at the head of the present Chambly Canal.

The cost of the undertaking has been variously estimated at from \$1,814,408 to \$4,267,890, the former contemplating a navigable depth of 9 feet, and the latter of 10 feet, with somewhat larger and more substantial locks.

The year before the canal commission made their report a company had been incorporated, with a capital of \$3,000,000, to build this canal.

The commission, while heartily approving of the undertaking, say that in view of the fact that it is in the hands of a private company with competent powers, they do not feel warranted in recommending any expenditure of the public resources upon it.

The company referred to has never taken any steps to carry out the purpose for which it was organized.

MONTREAL HARBOR—IMPROVEMENTS AND DEEPENING CHANNEL OF ST. LAWRENCE BELOW MONTREAL.

While a detailed description of the work done under government supervision on the various navigable rivers and harbors of the Dominion would be beyond the scope of this report, a history of the water communications of the Canadas would be manifestly incomplete if some mention were not made of the improvements which have been undertaken and carried through in the harbor of Montreal and the channel of the St. Lawrence, between that city and Quebec.

Although in speaking of it generally, Montreal, by reason of its position at the foot of the Lachine Rapids, was properly said to be the head of ocean navigation in the St. Lawrence, yet, in point of fact, until these improvements were commenced, vessels of 400 tons burden were compelled to lighten cargo in order to reach that city from the sea.

Such a condition of things was, of course, a serious embarrassment to the ambition of Montreal to become the center of the foreign commerce of Canada, and detracted largely from the value of the St. Lawrence system as the highway from the northern and western ports of the continent to the sea. The extent to which it operated to discourage foreign trade is indicated by the fact that up to 1825 there were in the port of Montreal only too small wharves, with a frontage of only 1,120 feet and a depth of only 2 feet of water, and in 1830 the greatest depth of dockage was 5 feet, and the frontage had not greatly increased.

In response to urgent demands for greater facilities the harbor commissioners of Montreal were organized, and the management of all matters connected with the improvements of the harbor confided to them.

Before the end of 1832 the wharfage had been increased to an aggregate frontage of 4,950 feet, or nearly a mile, with a depth of water varying from 5 to 20 feet.

In 1841 the board of public works of the United Provinces was authorized to improve and deepen the channel below Montreal, and during the five succeeding years \$300,000 was spent for the purpose under their direction.

In 1851 charge of the undertaking was transferred to the harbor commissioners of Montreal, who already had control of the improvements in the harbor proper, and by the latter part of 1853 a channel 150 feet wide and 16 feet deep was obtained.

During the next decade the work was steadily pushed forward, and in 1859 a depth of 18 feet had been reached, and in 1865 a channel 300 feet wide and 20 feet deep was completed.

In 1873 the Dominion Government was authorized to contract a loan of \$1,500,000 to defray the expenses of completing the channel to a depth of not less than 22 feet at low water, interest at 5 per cent., and a sinking fund of 1 per cent., to be paid annually by the harbor commissioners of Montreal out of the revenues of that port.

It was determined by the commissioners, after the work was undertaken, to make the depth 25 feet, and a channel of this depth was completed in 1882. Even before the formal opening of this channel it had been determined to increase its depth to 27½ feet at the earliest practicable date, so that the largest ocean steamers might be enabled to reach Montreal in safety. The General Government has already loaned the harbor commissioners \$900,000 at 4 per cent. to carry out this determination, and the work will be vigorously entered upon at the opening of navigation this year.

WHARFAGE FACILITIES AT MONTREAL.

During the period covered by these operations in the river itself the wharfage facilities had been gradually extended to keep pace with the increasing number and size of the vessels coming to this port from the sea, and the rapidly advancing foreign and domestic commerce of the dominion. There is now an unbroken line of wharves extending from Point St. Charles, above the entrance of the Lachine Canal, to Hochelaga, a distance of 3½ miles, with an aggregate frontage of 24,809 feet, or 4.17 miles, 16,458 feet of which have a depth of 25 feet, 2,391 feet a depth of 20 feet, and 5,960 feet of from 10 to 20 feet.

The earlier wharves were built of piles placed in a close row and backed with earth and stone filling. From 1846 to 1878 they were built entirely of cribwork, strongly framed of pine and other timber, and filled

and backed with stone ballast or the ordinary dredging from the harbor. Since 1878 open pilework has been used where there was no danger from violent shoving of the ice.

The whole work in the harbor proper has cost about \$3,000,000, of which only about half a million has been furnished by the Government, the rest being paid by the harbor commissioners.

The necessity of providing a revenue from which to pay the interest on the loans contracted by the harbor commissioners and the General Government to accomplish these improvements has compelled the exaction of large harbor dues and tolls. These are heavy taxes upon shipping and a great embarrassment to the carrying trade of Canada.

Efforts have been made from time to time to prevail upon the General Government to treat the deepening of the channel as a public work, and assume the debt already incurred, and carry on future operations, and thus make possible a substantial reduction in the dues.

Municipal and interprovincial jealousies have so far prevented any definite action being taken in this direction, but there is some prospect that the hopes of those who have been active in the matter will be realized, and the improvements of the St. Lawrence below Montreal be put upon the same footing as those above and made a public work.

CLOSING REVIEW OF THE CANAL SYSTEMS OF CANADA.

The spirit with which the vast undertaking which has been described was entered upon when Canada was small in population and feeble in financial strength, the unvarying courage and energy with which it has been pushed forward from step to step amid many discouragements and against formidable obstacles, and the magnificent results, looking at them in their physical and political aspects, which have been achieved are apparent from the foregoing narrative.

How far the construction and maintenance of these water ways, especially the St. Lawrence route, have operated to build up Canada and increase its foreign and domestic commerce and divert to Canadian channels the carrying trade of the West; in other words, how far the sanguine expectations of the projectors and promoters of these improvements have been realized, is a question not easily answered.

The canal systems of Canada have unquestionably fostered interprovincial trade, have built up local traffic, have bound more closely together the different parts of the province, and in earlier times did much to stimulate immigration and open up the country to settlement and cultivation. The Welland Canal in particular has been and still is the channel of a large and productive trade between the numerous and important lake cities and towns on both sides of the line. But the canals as they existed in 1871 were amply sufficient for the needs of local and interprovincial trade, and the promoters and advocates of the improvements and enlargements which have been completed since then, and upon which nearly \$20,000,000 have been spent, had in view something more ambitious and comprehensive than to provide for this.

The canal commission but echoed the sentiments expressed by the public men of the Canadas as early as the beginning of the century, and iterated and reiterated by the advocates of internal improvements from that time forward, when they say, "It only requires an energetic effort upon the part of the Dominion to make the St. Lawrence the great highway between the sea and the West, at the very base of the Rocky Mountains."

To secure for Canada all those advantages which the possession of

this magnificent natural water way ought to give it, to make the St. Lawrence route in its whole length the highway by which the surplus products of the West would seek an outlet to the sea, to put it into a position to compete successfully for the export trade of the continent with the various American lines of communication, have been the great objects which these works, particularly the recent enlargements and improvements on the St. Lawrence route, were expected to accomplish.

Just so far as these objects have been or shall be obtained, to the extent to which a fair share of the grain transportation of the continent has been or shall be secured by Canada, so far, to that extent, have the hopes of the men who planned and carried out these enlargements and improvements been realized, and the vast expenditure in capital and yearly outlay for repairs and interest which the country has submitted to been justified by the results. Judged by this standard it can not be said that the outlook is an encouraging one. The export trade of the continent consists, and must always consist to a large extent, in the carriage of grain. The Montreal Corn Exchange, in a recent memorial, says: "A nominal share of the grain trade of the continent is an essential element in the prosperity of all other business exports, inasmuch as without it the tonnage requisite to accommodate cattle, lumber, provisions, and other between-deck cargoes can not be obtained," and so far this year the grain export trade is absolutely dormant. Vessel after vessel, indeed all the ocean steamers which have left this port since navigation opened this season, have gone without sufficient freight to pay expenses, and there is little prospect of any improvement for the balance of the summer.

As to the cause of this most deplorable and disappointing condition of things there are various opinions among those who have given the matter attention and are most immediately interested.

The view most generally entertained is that the St. Lawrence route is at present handicapped by heavy charges in the form of ship and canal dues, wharfage dues, port-warden charges, and pilotage fees, amounting in the aggregate to an almost prohibitive taxation on carriage by this route from the interior to the seaboard. It is asserted that by reason of these charges grain can be carried from Chicago to New York for a cent or a cent and a half a bushel less than to Montreal, and the St. Lawrence route is placed at a great disadvantage, especially in comparison with its chief competitor, the Erie Canal, a disadvantage from which it can not recover until the Government remit the canal tolls on eastern-bound freight and assume the debt for the improvements in the channel below Montreal.

The Montreal Gazette, the leading administration newspaper of this province, says in a recent editorial:

The Government has now to determine whether the canal system is to be allowed to fall into disuse until it is finally abandoned as the through carrier, or whether it is to be maintained as a useful competitor of the railways. To make the canals an essential regulator of rail rates, as well as a reasonably successful competitor for the transportation trade, three things are requisite:

The abolition of tolls on all trade except that passing between American ports.

The assumption of the Lake St. Peter debt.

The reduction of charges at the port of Montreal.

Strenuous efforts are being made by the boards of trade of the leading cities along the St. Lawrence route and by the forwarders and shippers of grain and other produce to induce the Government to adopt a policy of free canals at once as the only way of saving to Canada its foreign commerce and of securing from the canals the benefits that are expected to accrue by their enlargement.

The Corn Exchange of Montreal say :

The St. Lawrence route has already lost and must continue to lose its normal share of the grain export trade of the continent unless these exceptional and onerous transactions are ameliorated.

On the other hand, Mr. Niall, the Dominion commissioner of inland revenue, in a recent report, in which he reviews the subject at some length and presents an interesting array of statistics, takes the ground that the struggle is not between the St. Lawrence and the New York State canals, but between land and water carriage, and that in this struggle the railways are fast outdistancing the water ways and will in the end absorb the whole of the traffic; and finds in this fact, rather than in any excess of charges, the explanation of the condition of the St. Lawrence route.

Although it can hardly be doubted that the actual cost, taking everything into consideration, of carrying a ton of wheat or grain from any of the lake cities to Montreal is less by water than by rail, yet it is said that, at the present time, so keen is the competition between the various railroads grain can be actually brought from the far West to Montreal by car for something less than by boat. While this condition of things continues traffic will unquestionably be largely diverted to the railways and the effect can not but be disastrous to the business of the water ways. The presumption, however, is that the economic laws which govern such matters will eventually assert themselves, and the railways will be compelled to maintain such rates as will make their business, if not actually remunerative, at least self-supporting. When the equilibrium is restored and when, by an abolition of tolls and a reduction of dues, carriers by the St. Lawrence route are enabled to compete in rates with those by other routes which are wholly or partially by water, it may be expected that traffic will again seek its natural channel and the country reap a part at least of the beneficial results which were hoped for when the canal commission's scheme was entered upon. It may be mentioned here that there is some opposition to the policy of free canals on the ground that it will benefit American producers only, and that the loss of revenue resulting from it will increase taxation upon Canadians.

One of the purposes had in view by the Government in determining that the least depth on the St. Lawrence route should be fixed at 14 feet was to enable the largest class of lake craft to carry their cargoes direct to Montreal without breaking bulk, and even to permit ocean-going vessels to go directly to Toronto and the lake ports.

Subsequent experience has, I think, modified the views of those who hoped for these results, and the consensus of opinion now is that the grain trade, which is, as we have seen, the real trade of the route, can not be profitably carried on in this way, and that the expense of taking an ocean vessel up through the various canals to Lake Erie and the upper lakes and bringing it back again, or of sending down to Montreal the large lake steamers, would more than overbalance the additional expense of several transshipments between the point of departure and the ocean.

Indeed the opinion is freely expressed by those whose judgment on the subject is entitled to weight that the enlargements and improvements in the St. Lawrence canals, not including the Welland, have not been of as much benefit to the grain trade as was expected, transportation by vessels small enough to pass the canals as they were in 1871, before these enlargements were made, being quite as cheap and in some respects much more convenient than by large vessels.

In submitting this report I desire to express my indebtedness for most of the facts stated in it to the general report of the commissioner of public works of the united provinces for the year ending June 30, 1867; the general report of the minister of public works of the Dominion for the period between June 30, 1867, and June 30, 1882; the annual reports of the commissioner of railways and canals since 1879; the report of the chief engineer of canals, submitted in 1880; and a large number of other papers and documents.

I have endeavored to seek out all the sources of information to which access could be obtained and to verify my statements in every way possible, and a large part of the time occupied in compiling this report has been devoted to efforts in these two directions. I could wish the results had been more satisfactory, but I submit them with the hope that they may not be altogether useless.

SEARGENT P. STEARNS,
Consul-General.

UNITED STATES CONSULATE-GENERAL,
Montreal, June 1, 1884.

APPENDIX A.—*Table of distances and sections of navigation and of obstructions on the St. Lawrence route.*

From—	To—	Sections of navigation.	Distance.	Obstructions.
			<i>Miles.</i>	
Montreal	Lachine	Lachine Canal	8½	Lachine Rapids.
Lachine	Melocheville	Lake St. Louis	15½	
Melocheville	Valleyfield	Beauharnois Canal	11½	Cascades, Coteau and Cedar Rapids.
Valleyfield	Cornwall	Lake St. Francis	32½	
Cornwall	Dickinson's Landing	Cornwall Canal	11½	Long Sault Rapids.
Dickinson's Landing	Farrano Point	River St. Lawrence	5	
Farrano Point	Croyle's Island	Farrano Point Canal	½	Rapids.
Croyle's Island	Morrisburgh	River St. Lawrence	10½	
Morrisburgh	Rapide Flat	Rapide Flat Canal	4	Rapide Flat Rapids.
Head of Rapide Flat	Iroquois Village	River St. Lawrence	4½	
Iroquois Village	Galops Rapids	Galops Canal	7½	Galops Rapids.
Head Galops Rapids	Prescott	River St. Lawrence	7½	
Prescott	Kingston	River St. Lawrence	59	
Kingston	Port Dalhousie	Lake Ontario	170	
Port Dalhousie	Port Colborne	Welland Canal (old)	27	Niagara River and Falls.
Port Dalhousie	Port Colborne	Welland Canal (enlarged)	20½	

APPENDIX B.—*Table of distances, sections of navigation, and obstructions on the Montreal, Ottawa, and Kingston route.*

From—	To—	Sections of navigation.	Distance.	Obstructions.
			<i>Miles.</i>	
Montreal	Lachine	Lachine Canal	8½	
Lachine	St. Anne's Canal	Lake St. Louis	14½	St. Anne's Rapids.
Foot of St. Anne's Canal and lock	Head of St. Anne's Canal and lock	St. Anne's Canal	½	
Head of St. Anne's Canal and lock	Foot of Carillon Canal	Lake of Two Mountains and river Ottawa	27	
Foot of Carillon Canal	Head of Carillon Canal	Carillon Canal	¾	Carillon Rapids.
Head of Carillon Canal	Grenville Canal	River Ottawa		
Foot of Grenville Canal	Head of Grenville Canal	Grenville Canal	6½	
Head of Grenville Canal	Ottawa City	River Ottawa	5½	Long Sault Rapids.
Ottawa City	Kingston	Rideau Canal	126½	Rapids and shallows and falls.

APPENDIX C.—*Table of distances, sections of navigation, and obstructions on Lake Champlain route.*

From—	To—	Sections of navigation.	Distance.	Obstructions.
			<i>Miles.</i>	
Montreal	Sorel	River St. Lawrence	40	
Sorel	St. Ours	River Richelieu	14	
St. Ours		St. Ours lock and dam		St. Ours Rapids.
St. Ours Lock	Chambly Basin	River Richelieu	32	
Chambly Basin	St. John's	Chambly Canal	12	Chambly Rapids.
St. John's	Rousse's Point	River Richelieu	23	

APPENDIX D.—*Table showing length of each canal, number and dimensions of locks, and dimensions and tonnage of vessels which can pass them.*

Locks.	Length.	No. of locks.	Lockage.	Locks.			Vessels passing through.			
				Length.	Breadth.	Depth.	Length.	Breadth.	Draft.	Tonnage.
	<i>Miles.</i>		<i>Feet.</i>							
Lachine	8½	5	45	270	45	12	250	44	12	1,000 to 1,500
Beauharnois	11½	9	52½	200	45	9	180	41	9	700
Cornwall	11½	7	48	200	55	9	180	54	9	750
Williamsburgh	12½	6	29½	200	45	9	180	44	9	800
Welland (new)	26½	26	326½	270	45	12	250	44	12	1,000 to 1,500
St. Ours lock	8	1	5	200	45	7	180	44	7	600
Chambly	8	9	74	118	23½	7	110	23	6½	230
St. Anne's lock	1	1	2	200	45	9	180	44	9	700
Carillon	5½	2	12½	200	45	9	180	44	9	700
Grenville	5½	5	45½	200	45	9	180	44	9	700
Rideau	126½	47	(*)	134	33	5	120	31½	4½	250

* Rise, 282½; fall, 164; 446½.

NOTE.—The depth given in the average depth at low water. When the water is unusually low this depth can not be maintained, and the capacity of the canals is reduced.

BRITISH COLUMBIA.

REPORT BY CONSUL STEVENS, OF VICTORIA.

GEOGRAPHICAL AND GEOLOGICAL.

British Columbia is to a certain extent trough-shaped, for whereas the coast is margined by the lofty parallel ranges of the Cascades, and the eastern border is guarded by the Rocky Mountains, range beside range, the interior consists of a great hill-broken valley, drained by two great water courses, the Fraser and the Thompson Rivers. The latter is in reality a tributary of the Fraser, into which it empties at Lytton, but it occupies a wide valley and drains an important lake system in the southeastern part of the province, while the main stem of the Fraser comes from the far north to Lytton, where the combined currents break their way through in a westerly direction to the coast, forming the magnificent Fraser Cañon. It is the valley of the Thompson, and afterward the Fraser Cañon, which the Canadian Pacific Railway takes advantage of to make its picturesque passage of the multiplied coast ranges.

This southern central interior of British Columbia has one of the driest climates on the continent, although you can see snow-covered mountains in all directions (except south) from almost any hill-top, and will see portentous rain clouds coursing overhead and discharging their contents on the distant heights. This is due to the fact that the rain clouds, drifting in from the Pacific, are arrested by the lofty Cascades, condensed by their cold summits, and deprived of a large part of their moisture, while the remainder, buoyed up in the rarefied, equable, and steady currents of the upper air by the volumes of heated atmosphere always ascending from the dry plains, drift over to the Rocky Mountains before they encounter any interference sufficient to precipitate the residue of moisture. Two circumstances result—one, the absence of forests, which there is not rainfall enough to support; and, second, the

great size of the rivers which flow steadily and strongly, supplied by the abundant snows of the bordering mountains right across the intervening valley. As all these rivers were more fully fed and stronger in past ages than now, and as the whole country has been undergoing elevation, the rivers have been able to cut deep channels, and both the Fraser and the Thompson now flow some hundreds of feet below the general level of the country.

The elevation of the district appears to have ceased from time to time and then to have gone on again, for the lofty banks of the rivers, especially in places where they have a cliff-like steepness, show a succession of well-marked terraces, one above the other, which can be traced for a long distance as plain as one can see the railway embankment. From just below Kamloops, where the North Thompson comes into the South Thompson, and where a trap dike dams the water back into a beautiful lake, down nearly to Lytton, these terraces form a very striking feature of a landscape which is one of the most curious in America. The train runs upon a sinuous ledge cut out of the bare, irregular south side of the Thompson, where the headlands are penetrated by tunnels and the ravines spanned by lofty bridges. In the purity of a trout brook the river whirls down a winding, torrent path, as limpid and green as an emerald. Sometimes are rounded cream-white slopes, next cliffs of richest yellow, streaked and dashed with maroon will jut out; then masses of rust-red earth, suddenly followed by an olive-green grass slope or some white exposure. With this gay and fantastic color, to which the doubly brilliant emerald river opposes an artistic contrast, and over which bends a sky of deepest violet, there goes the additional interest of great height and breadth of prospect, and a constantly changing grotesqueness of form caused by the water and wind wearing down rocks of unequal hardness into odd monumental semblances and other phases of mimicry, reminding one of architectural human or animal figures. Near Ashcroft the rocks are overlaid with great deposits of stiff clay, in which the action of the atmosphere and of the streams of water which follow the occasional deluges, that now and then fall with tremendous energy, had worn deep gullies, and left a strange ruin of Titanic towers, spires, and broken walls, which blaze with strong light on one side and cast sharp and fantastic shadows on the other. Not all the scenery is cast in this grotesque mold, but the strange forms and gaudy hues of the rocks, the clay cliffs, and the scantily herbage terraces through which this grass-green river races, impress themselves most strongly on the memory. There is plenty of evidence of life.

MINING AND FARMING.

Kamloops is a flourishing town of 2,000 or 3,000 people, and steamboats ply along the river and lakes above and below it. Lower down we see many ranches, and a wagon road was long ago cut into the cliffs along the lower Thompson to form one of the routes to the Cariboo district, which still accommodates considerable travel, while colonies of Chinese are busily engaged here and there in washing the river gravel for gold. Ashcroft, a modern town with several hundred inhabitants, is the supplying point for farmers, cattlemen, and miners, and the point of departure for Cariboo, Barkerville, and the well-settled gold mining region of the northern interior. Farming here, however, can only be done by irrigation, and the fact that most of the streams flow in deep channels renders irrigation difficult and expensive, except for limited areas of bottom land.

Fruit-raising succeeds wonderfully well. The hills and treeless valleys are covered with nutritious bunch grass, and grazing will always be the most important industry, an industry which is constantly on the increase over the wide area between the Thompson River and the United States boundary, as well as somewhat to the northward.

The foregoing description by Ingersoll can not be surpassed by any effort of mine. I confirm it and submit it. It corroborates previous dispatches in which I have had occasion to portray this section with reference to its agricultural possibilities. It will be seen that only water and transportation are needed to quickly people the country and make it valuable.

IRRIGATING DIKES AND DITCHES.

I have ever since my residence here known that efforts more or less extensive have been made to fructify the foregoing described section and its adjacent country by irrigating ditches, some of which I have seen, reminding me of the caños I saw long since in that other Colombia, then known as Nueva Granada.

Sir Matthew Begbie has recently mentioned to me one of these, commenced as long since as 1867, which was, or was to be, 14 miles in length. This I presume was the enterprise of an American, W. H. Lawford, called "Boston," that city being his native place, of which I have heard from other sources, but am unable to glean anything more definite, and I am told that the project was a failure, "broke him up," as the people here have it, and only in part now supplies the want for which it was intended. There are others of similar nature, information of which is impracticable.

As early as 1873 "An act respecting drainage and diking and irrigation of lands in British Colombia" (36 Victoria) was passed. This provides with great particularity for the appointment of commissioners, specifies their powers, and directs them how to carry on the work; for cases in which the land is partially owned by the Crown; for overseers; notice to proprietors; how and for what assessments, fines, and rates are to be made; that lands may be leased or sold for payment of rates; that that land only is liable where the owner has not agreed to the works, for actions by owners against commissioners; that owners and occupiers shall furnish labor; fine for neglect for assessment of damages for sods or soil; record to be kept by clerk; fees for inspection and extracts; for cases of salt marshes and necessary break waters; assessment only upon land benefited. Clerks to be competent witnesses, commissioner not to be a clerk; how to obtain plans; outer dikes and inner dikes; how kept, outer dike ceasing to protect inner. Proprietors of inner dikes recourse to compel repairs of outer dikes; injured dikes, how repaired; mode of making application for drainage—duty of commissioner; mode of valuing and assessing damage to lands—cases of two proprietors, but neither owning two-thirds, how provided for; occupant may appeal to Supreme Court; fines for official neglect; verbal notices valid unless otherwise specified; commissioners not liable for acts of predecessor; lieutenant-governor in council may in certain cases guaranty interest on two-thirds money for diking; assessments for the interest so guaranteed, lien on the land therefor.

The "Sumas diking act, 1878," amended in 1883, and again April 28, 1888 (Victoria 51), is intended for the relief of the settlers and owners of land upon Matsqui Prairie. As its object is in a degree within the inquiry of the circular I am now answering, and may in a measure "contribute to the complete illustration of the important matters embraced by the resolution" it covers, I give here a partial synopsis of a prospectus pertinent.

MATSQUI LAND COMPANY.

From a prospectus just issued it is seen that a company has been formed for the purpose of repairing the Matsqui dike works in accordance with the Sumas dike act, 1883, and for purchase of parts of the land reclaimed thereby.

The lands lie on the south bank of the Fraser River, some 30 miles above New Westminster, and about the same from the center of the district described in my dispatch. By an act passed in 1878, a Mr. Derby was permitted to dike in the whole of the river lands at Matsqui, and to thus acquire a large extent of the country. Neighboring land holders were obliged by the act to pay him an assessment varying from \$2.50 to \$4 per acre, according to the situation of their farms, and the benefit accruing from the construction of the dike.

The highest freshet known to have occurred in the Fraser prior to

1878 was in 1876, and Mr. Derby was required by the act to build a dike sufficient to prevent a similar overflow. He did this, building a dike a foot higher than the 1876 level. The work was completed in 1881 and cost \$70,000, it being 7 miles long with a breadth at the base, where the land is low, of 40 feet. In 1882 the water rose about a foot higher than 1876, and overtopped the dike at the upper end, making several breaches and bursting two flood-gates across the mouth of the sloughs. With this exception the dike stood splendidly and proved to have been thoroughly well built and adapted to the purpose. Nevertheless the enterprise is now suspended for want of means.

Two experienced engineers have recently inspected and reported on the feasibility of the diking works being placed in thorough repair and increased in height. They estimate that all work necessary to replace bulkheads, stockades, and increase the height along its entire length, including off-take drains in the rear, and all repairs, will cost no more than \$40,000. If the convenient sloughs may be made available for off-take drains, the estimate will greatly be reduced. The present dimensions of the dike are 4 feet in width on top, and slopes of one and one-half of one, and it is proposed to raise it 2 feet above the present level, which will give a height above the flood line of 1872.

It is, as I believe, reliably stated that some 12,000 to 14,000 acres of land will be made available under the dikage act, at a value of from \$25 to \$35 per acre.

Previously to preparing this dispatch, I addressed notes to ex-Governor Cornwall, Government Agent Soues, and others, so that the information which I might forward to the Department would be as comprehensive as possible. In this manner I fully expected to secure a great deal of information in regard to irrigating canals or ditches. My expectations, in this regard, have not been as fully realized as I had hoped. The two communications herewith were the only answers received.

Ashcroft is the residence of Cornwall, the late chief executive of the province, who has a fine pack of hounds and can give a veritable coyote hunt to his visiting friends. Thaddeus Harper, of Virginia, a large stock-raiser, also resides there.

Government Agent Soues to Consul Stevens.

GOVERNMENT OFFICE, CLINTON, BRITISH COLUMBIA,
September 30, 1889.

DEAR SIR: I beg to acknowledge the receipt of your letter of the 27th instant, asking for information on behalf of the Department of State, for the United States, regarding canals for transportation and irrigation in this province.

In reply, I beg to say that I am not aware of the existence of any canals in this province for the purposes of transportation.

With regard to irrigation, I may say that from the eastern slope of the Cascades to the western foot hills of the Selkirk Mountains there is a large extent of arid country, valueless for the purposes of cultivation, without the artificial use of water by means of irrigation. The term canal, when applied in connection with irrigation, and as it would be understood in some of the States of the Union—notably California—is unknown in this province.

In the portion of the province above indicated, land suitable for cultivation is situated, as a rule, in the numberless small valleys, and generally of limited extent, and the water used for irrigation is drawn from the nearest available mountain stream.

The legal title to water for this purpose is governed by provincial statute, to which I beg to refer you (see volume 1, Consolidated Acts of British Columbia, 1888, chapter 66, section 39, *et al.*). Looking these over you will see at once that the term canal does not apply to irrigation in this province. Any further information that I can give I shall be most happy to furnish you with at any time.

I have the honor to be, sir, your most obedient servant,

F. SOUES,
Government Agent.

Mr. Cornwall to Consul Sterens.

ASHCROFT, BRITISH COLUMBIA, *October 14, 1889.*

DEAR SIR: I regret that I can not communicate anything of importance to you with reference to irrigation canals or ditches.

Throughout the dry portion of the interior of this province commencing, say, at Lytton on the Fraser River, and extending northward as far as Alexandria on the same river and eastwards to the Okanagan and Similkameen districts, irrigation is universally adopted as a necessary assistance to the cultivation of crops, but in the generality of cases only streams of water passing through or near by the lands to be irrigated have been utilized, and as the necessary ditches, etc., for such use of water have in all cases been the work of individuals, or at all events of two or three partners, it may be easily understood that nothing of great magnitude or importance in that line has been attempted; at the same time there are ditches of considerable length working—for instance a settler in this immediate neighborhood has diverted the waters of Hat Creek to irrigate his farm on the banks of the Thompson River, having for that purpose to make a ditch, say, 4 miles long, with a long stretch of fluming and to draw up the outlet of a lake, the whole work costing him perhaps from \$4,000 to \$5,000.

And there is the case to which you refer, where one W. H. Sanford attempted to bring water from the Buonaparte River on to his farm near here, a distance of some 10 miles, and at a cost of about \$60,000.

But his undertaking resulted in failure, owing to his working with incorrect gradients. There are also other instances in this neighborhood of ditches of considerable length, but they are hardly works calling for notice.

Further up the country there exist, as you have been informed, ditches, etc., of considerable length, and doubtless constructed at some expense, but I regret to say that of them I have no personal knowledge which I can communicate. I foresee that the time will ere long arrive when much of the water which in many parts of the country is available for irrigation will be utilized through the means of the provincial government or associations of capitalists, but at present no apparent necessity for anything of the kind has presented itself, nor have any steps in that direction been taken.

Although, as you will observe, I can not give you very much information as to "the extent" of irrigating canals, I can say something of their "use" and "the benefit derived from them."

Their use throughout the portions of the province above referred to is universal, and the benefit derived is patent; without irrigation the cultivation of the soil in such portions would be fruitless; with it the most satisfactory results are attainable and attained. It is hardly necessary to explain that where a farmer, secure as he is in such portions of a sufficiency of summer heat for the ripening of the crops he cultivates, has at his command, and to be applied at any time when needed, the necessary moisture, his success with ordinary prudence is assured. Such is the case, and although irrigation of land undoubtedly adds a certain percentage to the expense of cultivation, yet I think it can be indisputably proved that the advantages resulting from its use amply repay the increased cost. The average yield of crops under well-applied irrigation is very large; far larger than in unirrigated districts, however fruitful they may be. The use of the water, doubtless to a certain extent, enriches the land, and so rapid is growth under its beneficent and stimulating effects, that in these comparatively northern latitudes produce is brought to a perfection of species which you would only expect to find flourishing in more southerly climes; for instance, besides all the usual grains and roots common to temperate climes, in these districts, under irrigation, flourish fruits of all descriptions—grapes, melons, cucumbers, tomatoes, maize, apples, pears, plums, etc., all too numerous to mention—and attain a maturity and perfection which is astonishing. Such would not be the case were such latitudes subject to the cold which is associated with a degree of rainfall which would render irrigation unnecessary. I think that most farmers who have experienced practically the advantages of irrigation would be unwilling to pursue their avocation in districts where its use was unnecessary or impossible.

With renewed expressions of regret that I am unable to furnish you with more specific information in the direction you seek,

I have the honor to be, dear sir, your obedient servant,

C. F. CORNWALL.

In running over the dispatch it has occurred to me that the vivid description of the irrigated country might be credited to the wrong Ingersoll. The Ingersoll who wrote is Ernest Ingersoll. The remarkable similitudes, "monumental semblances and phases of mimicry," described

are, however, surpassed in many places in the United States, notably in Idaho. I saw in 1873, near the Snake River, just after leaving the station called "Dooms," a sandstone formation resembling the Acropolis, and in the same journey, one day's staging from Reno, on the Central Pacific Railway, what was called the "City of Rocks," almost as remarkable as the Giant Causeway.

ROBERT J. STEVENS,
Consul.

UNITED STATES CONSULATE,
Victoria, October 24, 1889.

SOUTH AMERICA.

BRAZIL.

REPORT BY CONSUL BORSTEL, OF PERNAMBUO.

WATER WAYS.

No canals exist in this consular district nor are any to be built here for some time to come, in fact I do not think that canals will even be of any use here, owing to the formation of the land and the want of lakes or rivers which could be joined by canals to the great advantage of traffic or commerce, and canals for the purpose of irrigation are not needed in a country where the annual rainfall at times reaches between 80 and 90 inches per annum.

All traffic is carried on here by very primitive river craft called *barcassos*, and said craft are also used to do coasting business, because they are protected by a coral reef which encircles the coast of this whole consular district, with occasional openings to admit ingress or egress to and from the ocean; this coral reef is about one-half of a mile from the mainland and forms a mighty barrier against the encroachment of the ocean upon the land and offers these *barcassos* the protection of a river.

In the interior, traffic is carried on by horses; they have the merchandise slung on each side of them; they rest in the middle of the day and travel at night, making only a short stop at midnight; this requires constant loading and unloading of the merchandise, and I would respectfully say just here that the American exporters sometimes lose entirely sight of this fact and export their goods in such frail packages that they will not bear the handling on a long journey of that sort, and are, therefore, not so readily sold as European goods, where the exporters are aware how said goods reach the interior; note, for instance, the importation of flour in this consular district, which amounts to about 200,000 barrels per annum; this was formerly all sent from the United States, but now Austria supplies one-half of this amount direct from Trieste in two Austrian lines of steamers lately established. Whether this change is owing to the Austrian flour being better than flour from the United States I will not say, but one thing is sure, an Austrian barrel of flour while it does not look on the outside as well as an American barrel, still this barrel is better filled and stronger, so much so that should any Austrian barrel of flour fall accidentally 20 feet, both heads would still be in the barrel when it lands; but should an American barrel fall 10 feet both heads would be out when it lands. It will be seen, therefore, at once, if an American barrel of flour and an Austrian barrel of flour

start on the same journey by land the Austrian barrel will arrive at its destination in good order and the American barrel will have to be coopered half a dozen times on the journey, owing to the constant loading and unloading of the horses on their way to the interior. This same rule holds good in some instances of other American goods imported here.

H. CHRISTIAN BORSTEL,
Consul.

UNITED STATES CONSULATE,
Pernambuco, October 14, 1889.

BRITISH GUIANA.

Demerara.

REPORT BY CONSUL WALTHALL, OF DEMERARA.

The terms "canal" and "trench,"* used somewhat indiscriminately, as heretofore occurring in this and, previous report, are applicable almost exclusively to those made and maintained by private enterprise for the internal transportation or drainage of particular estates. There are only three short canals in the colony—so far as I am informed—constructed for purposes of public travel or traffic, or so used, except to a limited extent, by consent of their proprietors or managers. There are, however, a number of canals constructed and maintained for the purpose of introducing a supply of water from the streams, swamps, and savannas of the interior to the cities, towns, villages, and plantations of the coast.

Probably the most important of these is the Lamaha Canal, by which the city of Georgetown and a number of sugar estates in the vicinity are supplied with water from the Lamaha Creek and its affluents. This canal is about 23 miles in length and 60 feet in width, with an average depth of 5 feet. Its construction—commenced about 60 years ago—was effected by means of contributions of labor from the parties interested, aided by loans of money from the Colonial Government, the interest on which and the expenses of its maintenance, enlargement, repairs, etc., are met by assessments levied on the city and the estates interested. The management is vested in a committee of six persons, of whom three are chosen by the municipal council of Georgetown, and three by the proprietors of estates, with the high sheriff of the county (Demerara) in which the canal lies, as *ex officio* chairman. The quantity of water allowed each party is practically unlimited in very rainy seasons when the supply is abundant, but in the dry seasons is regulated by permitting the various "kokers" to be opened only a certain number of hours in each month, the time being apportioned mainly according to the quantity of labor originally contributed to the work by the respective estates. The city of Georgetown being situated at the terminus of the canal, these restrictions do not seem to apply to the quantity of water to which it is entitled therefrom.

There are several other canals constructed and managed on the same or similar general principles, for the benefit of particular districts of the colony. To obviate the risk of failure of the water supply from

* See consul's supplement to his report on irrigation.

the streams, lakes, and swamps in the dry seasons, dams or "stop-offs" are built in some places, constituting extensive and permanent reservoirs in the rear of the cultivated lands on the coast. The water brought from these, by means of canals and sluices, is employed, not only for the internal navigation of plantations—as already explained—but (especially in towns and villages) for various domestic purposes, including, in seasons of protracted drought, when the rain water in tanks and cisterns is exhausted, even the drinking uses of some of the inhabitants.

W. T. WALTHALL,
Consul.

UNITED STATES CONSULATE,
Demerara, November 8, 1889.

COLOMBIA.

REPORT BY VICE-CONSUL WHELPLEY, OF BARRANQUILLA.

In reply to Department circular of May 2 on irrigation and water supply, and the one of July 31 on the kindred subject of canals, I have the honor to state that there is no system of artificial irrigation in operation in this consular district, and I believe no enterprise of that nature in the country, with the exception of such small ditches as may be in use in some mining locality for sluicing.

There are no canals. In 1783 a monk of Novita opened a narrow water way for canoes between the headwaters of the rivers San Juan, on the Pacific side, and the Atrato, on the Atlantic, called the canal of "Raspadura." With that exception, and the "Panama," there are no records extant of canal construction.

Barranquilla has for waterworks a Cornish pumping engine, old style, taking water through a 12-inch main from another pumping engine on the margin of the Magdalena River, a mile distant.

Its distribution, by the "Cornish" hydraulic, is on the "Holly" or direct system, the surplus reaching a small storage reservoir back of the town, 120 feet above the river level, intended to hold a week's supply in case of necessity for repairs to engines.

It is a private enterprise. Householdiers using the water pay \$3 a month.

The poorer class, having their own "burros" and water barrels, have the water carried from the Caño, a branch of the river in front of the town. Probably about one-third of the resident population patronize the "water works" owned and controlled by a syndicate of foreigners. The plant of the enterprise was from England; the valves and gates and the connections are such as were discarded 20 years ago in the United States.

Information obtainable here, on the subjects mentioned, is of no interest or value whatever to the Department.

P. M. WHELPLEY,
Vice-Consul.

CONSULATE OF THE UNITED STATES,
Barranquilla, September 13, 1889.

FRENCH WEST INDIES.

GUADELOUPE.

REPORT BY CONSUL BARTLETT.

CANAL DES ROTOURS.

This canal is about 8 kilometres, in length. It extends from the Bay of Port Louis to a little village called Gripponin the commune of Morne-à-l'Eau, at about half way between Pointe-à-Pitre and the Moule.

This canal was dug for the purpose of transporting canes and sugar from the different estates in that vicinity to Pointe-à-Pitre, via the Bay of Port Louis and la Rivière-Salée, and in return plantation supplies are taken back.

The Canal des Rotours was constructed between 1825, and 1830, by the Baron Angot des Rotours, vice-admiral, then governor of Guadeloupe.

When first commenced the Government's intentions were to have constructed this canal from the Bay of Port Louis to the Moule, a distance of about 20 kilometres; but owing to political difficulties which took place in 1830, the canal was abandoned after reaching as far as Gris-Pont.

It is reported that the digging of this canal caused the death of three convoys of negroes from the coasts of Africa, owing to its being situated in a very marshy tract of land.

The enterprise having been abandoned, the Government leased the canal to a company for 60 years, from 1830 to 1890. This lease expires next year. Then the canal will revert to the owners of the plantation through which it passes, and which, on account of mortgages, now belongs to the Credit Foncier.

The depth of the waters of the canal at present is about 5 to 6 feet.

LA RIVIÈRE-SALÉE

Is a natural canal which separates Guadeloupe proper from Grand Terre, about 6 to 7 miles in length, connecting the harbor of Pointe-à-Pitre, at its southern entrance, with the bay of Port Louis and the sea at its northern entrance; its breadth varies from 30 to 120 metres, and is navigable for vessels of 8 to 10 feet draft.

No foreign vessels are allowed to pass through Rivière-Salée without a special permit, although it is the natural route for all droghers and coasting vessels and steamers of the island.

LAMENTIN CANAL

Is a short canal of about 1 kilometre in length, extending from the Bay of Lamentin to the village of that name. It is used for the conveyance of canes and sugar from the plantations of that commune to Pointe-à-Pitre, via Rivière Salée.

There are, all over Guadeloupe proper, ancient canals constructed during the last century. Some are several kilometres in length. These canals were constructed to convey water from the rivers or watersheds

to the different sugar plantations for the purpose of working their sugar mills. Some of these canals were dug by several proprietors of small plantations, combined, each proprietor having a limited time for making use of the waters. The proprietors of larger plantations constructed their own canals, but the greater part of these ancient canals has been abandoned since the construction of large usines or central sugar manufactories.

There are in Guadeloupe no canals for irrigating purposes, and they are not required.

CHARLES BARTLETT,
Consul.

UNITED STATES CONSULATE,
Guadeloupe, September 9, 1889.

CONTINENT OF ASIA.

JAPAN.

THE KIOTO AND LAKE BIWA CANAL.

REPORT BY CONSUL SMITHERS, OF OSAKA.

This important public work was formally opened by His Imperial Majesty, the Emperor, on the 9th instant. The canal is designed to connect Lake Biwa with Kioto, which has a waterway extending to the Bay of Osaka. The length of the canal is $6\frac{7}{8}$ miles, and has been constructed in 5 years, entirely under the supervision of a Japanese engineer.

Lake Biwa has an area of 500 square miles and is situated 280 feet above the sea level, and is 143 feet above the level of Kioto. The canal has three tunnels, the largest being over $1\frac{1}{2}$ miles. They are lined throughout with masonry and brickwork, and have a breadth of 16 feet and a height of 14 feet. There are no towpaths in the tunnels, the canal boats being propelled through them by a chain laid at the bottom of the water. For the most part the canal is constructed by making cuttings and embankments along the sides of the mountains, and is lined throughout on the inside by substantial stone masonry.

At a distance of about 5 miles from the lake, in order to overcome the difference in level between that point and the plane of the city (being 120 feet in a distance of 1,800 feet) the boats are hoisted into a cradle, running on a railway track, and are pulled up and down by means of a wire hawser, worked by water power from the canal above.

In addition to opening a route of canal navigation from lake Biwa through Kioto to Osaka, one of the largest commercial centers in Japan, it is proposed to utilize the water power at Kioto for manufacturing purposes, for lighting the city by electricity, and for irrigating the rice fields.

The cost of the canal when entirely completed, as stated in the report of Mr. Tanabe, the able engineer, is estimated at one million and a quarter silver yen, a sum which would be totally inadequate to construct such a work in the United States.

E. J. SMITHERS,
Consul.

UNITED STATES CONSULATE,
Kioto and Osaka, April 12, 1890.

[Inclosure in Consul Smithers's report, from the Hiogo News, of Saturday, April 12, 1890.]

We have obtained some further and interesting particulars concerning the opening of the Kioto-Biwa Canal from a Kobé resident, who was a favored guest at the ceremonial. Among the foreigners present were Mr. E. J. Smithers, United States consul here, Admiral Belknap, of the United States squadron in these waters, and his flag-lieutenant, Mr. Norris. The Kobé contingent of visitors proceeded to Kioto, where, in consequence of an anticipated detention on the line, they took jinrikisha to the head of the canal at Lake Biwa, the whole way being lined with troops, and all ordinary traffic stopped. Arrived here they found no less than some 30 house-boats expressly provided to convey visitors down the canal to Kioto, a handsome boat having been built for His Majesty, and in which boat Admiral Belknap had been asked to make the journey of the canal in company with the Emperor. His Majesty, however, as we know, did not take kindly to the water portion of the programme, and the visitors made the passage by themselves, the first boat ever to make the journey of the canal being that containing Mr. Smithers, Admiral Belknap, and Flag-Lieutenant Norris. The passage to Kioto was easily and comfortably made in about one hour and three-quarters. About one-half hour after leaving Otasu the tunnel was entered, and this had been lit throughout its entire length with electric light in anticipation of the Emperor performing the journey by water. The depth of the canal on the occasion of which we write was about 4 feet of water, but its dimensions will allow of an additional depth of 2 or 4 feet more. The banks throughout are faced with stone, and the work, we learn, reflects great credit upon those charged with its conception and execution.

CHINA.

REPORT BY CONSUL PETTUS, OF NINGPO.

CONSTRUCTION.

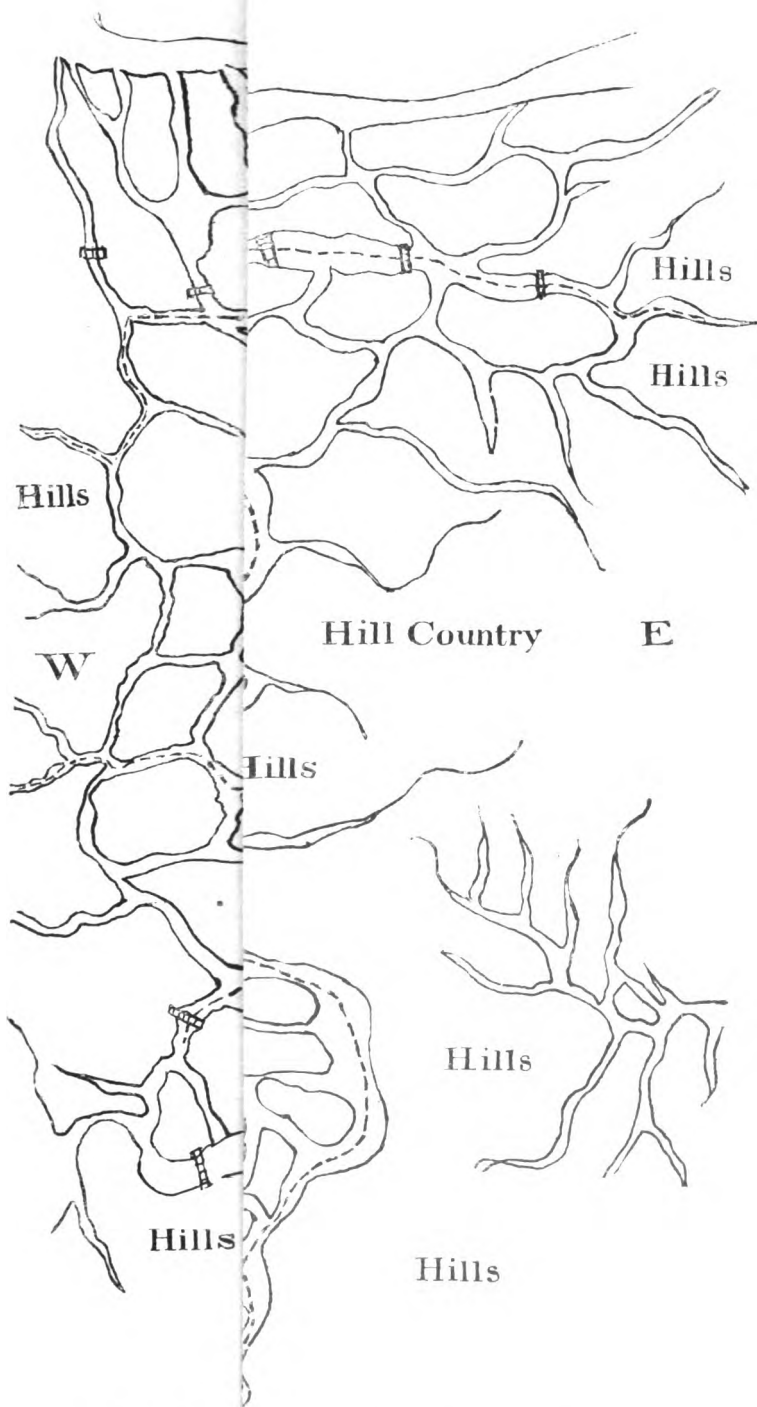
The history of Ningpo gives the time of construction of the first canals in this district 400 years B. C. That the principal canals were natural outlets from lakes and swamps, the soil being alluvial, the same as the great valley of our Mississippi; hence the first canals were like the bayous of Louisiana, their flow into the river being obstructed by dams at the mouth. Other canals were then excavated leading to and being supplied by these main arteries.


EXTENT AND CAPACITY.

They extend all through the valleys of China; all shipping to the port of Hangchow, 140 miles north of this, is by canals. Very few junks can visit its port, owing to rocks, shoals, etc., at the entrance of its harbor. A large trade is done by this city with Hangchow, all produce being carried by boats that are made to navigate the canals. At Hangchow the canals of this district connect with the Grand Canal, which leads as far as Peking. Almost every farm in this district has its canals for transportation and irrigation. We have no means of carrying in this district except by canal in the valleys and coolie carriers over the hills; no wheel or other carrying vehicle except the sedan chair, carried by coolies.

CANAL TRAFFIC.

There are many varieties of boats for traffic on these canals; the larger boats being from 40 to 50 feet long, about 8 feet beam, capacity some 15 tons. These are used for the larger canals. Then another class of boats 30 feet long and 6 feet beam, carrying 8 to 10 tons, varying in size to the small foot boat, used in visiting the outlying farms and gardens. On the main canals during the day as far as the eye can



The canals shown (thus ) are the canals said to have been in existence 400 B. C. The smaller

see are boats going and coming filled with freight and passengers. As to the extent of trade by these canals, it is impossible to ascertain. From the Chinese customs we find in 1888 there was distributed by these canals 115,644 pieces of cotton goods, 353,880 gallons of kerosene oil, and other imports in proportion, to the outlying towns and cities of this district. The transportation of tea and other native products which pass through the lekin stations or interior customs, which are under the control of native officials can not be got at, but is immense.

MANAGEMENT AND FREIGHT RATES.

The management is by the native officials. The navigation is free. Their principal duty is to see there is no obstruction to navigation and keep up the repairs.

I can only give the rates to Hangchow, as it is the principal city which transports freight to and from this city. It is 140 miles from this port. The cost of freight to this port is about 50 cents per cwt. The cost is greater on this route from the fact that many haulovers take place, that is, to haul over from one canal to another, and from the river to the canal. Then there are 5 miles to transport the freight by coolies at Hangchow. The overland transportation by coolies from Feng'hua to Taichow, distance 100 miles, cost \$1.15 per cwt. But the freight is much lower on the Grand Canal, where there are few haulovers. Passenger rates are very low. Our missionaries do nearly all their traveling by canals. They take their bedding and provisions on the Chinese boats and travel very cheaply; as for instance, the fare from this to Hangchow is about 70 cents.

IRRIGATING CANALS.

Canals in China are more numerous than the roads in our most populous States. Branch canals are excavated from the main canals at short distances, from 100 to 300 yards. These canals run at right angles from the main arteries, so that all the farms and gardens can be irrigated, which is done by wooden chain pumps made to reach the water from the bank. They are worked by hand or ox. So all farms in the valley are irrigated, always insuring a good crop of rice.

The boats are propelled on these canals by a process called by the Chinese "Yo-lu," that is, sculling, using 2 or 3 men with oars for this purpose. They also use sails, which, when the wind is fair, cause the boats to make 6 or 7 miles an hour.

Numerous bridges cross the canals, mostly of stone. The canals are thickly settled with villages. You never go more than 3 miles on the canals without coming to a village; all seem busy and full of life at every village or large farm house where the canal is bridged.

Accompanying is a drawing which will give some idea of the extent of canals in this portion of this province. In the northern portion they are still more numerous.

THOS. F. PETTUS,
Consul.

UNITED STATES CONSULATE,
Ningpo, September 25, 1889.

A chart showing the courses of the principal canals of the district of Ningpo according to the Chinese (not published) accompanied above report.

H. Ex. 45—5

THE IMPERIAL CANAL.

REPORT BY CONSUL JONES, OF CHINKIANG.

The imperial canal of China, known the world over as the Grand Canal, which extends from the ancient city of Kwa-chow, some 3 miles above Chinkiang to Peking, a distance of 650 miles, is a work of various ages, and is but partially artificial.

The original object of its construction was to supply the capital with food during the times of the predatory wars of the Mongols, and its only use during the greater portion of the distance is to convey to the capital the rice tribute from the provinces adjoining the Lower Yangtsze River, and is known amongst the Chinese as the Yun-liang Ho (the Grain-Bearing River).

The portion of the canal from Kwa-chow to Tsing-Kiang-pu, about 100 miles, where it formerly crossed the old bed of the Yellow River, dry since 1854, when the river, at a flood, deserted its former bed and made a new channel to the Gulf of Pechili, is mainly natural, and dates back to some seven centuries B. C. The intermediate part between Tsing-Kiang-pu and Liu-Tsing-Chow, in the extreme north of the province of Shantung, is for the most part artificial, and dates from the Yuen dynasty, in the early part of the thirteenth century.

From Liu Tsing-Chow to Peking the canal occupies part of the course of the river Wei, more or less navigable as far as Wei-king fu, in the province of Honan. From Tientsin to Tung-Chow, in like manner the grain is carried along the Peibo River, and from Tung-Chow to Peking, a distance of some 14 or 15 miles, advantage has been taken of the bed of the Hwen-ho River to form a water passage, through which the rice, transferred to small boats, is dragged with difficulty.

The first portion of the canal is mainly formed by connecting a string of lakes, of which the Kao-Yü and the Pao-Ying are the principal, by a series of short canals, the largest of which extends from the former discharge of the Kao-Yü Lake from Kwa-chow to Yang-chow.

To prevent the flooding of the lower country, an important line of embankment has been formed all the way from Yang-Chow to Hwei-an-fu, a distance of about 100 miles. This embankment is the principal and indeed it may be said the only important engineering work in connection with the canal. It is in places from 20 to 30 feet high, with a width at the base of 100 feet, and is pierced by numerous overflow or irrigating sluices. With this exception there were no material obstacles to be overcome in the construction of the canal requiring engineering skill. The chief labor was in cutting the connecting links and in building the embankments, on which, we learn, 300,000 men were at times employed.

The river Hwai (distinct from the Wei spoken of above), which drains the greater part of the province of Honan, and much of that of Anhui, formerly flowed past the town of Hwai-an-fu into the Yellow Sea, having in its course formed the large body of water known as the Hungtsze Lake.

At some time previous to the twelfth century, by digging connecting channels the waters of the Hungtsze Lake were led into the Kao Yü, and the lower course of the Hwai, from the Hungtsze to the sea, became in consequence silted up. Prevented by the embankment above mentioned from spreading over the lower country, they were led along the line of the canal to the neighborhood of Yang-Chow, some 20 miles north-

east of Chin Kiang, whence they found their way to the sea by the town of Sien-nü-miao, partly flowing into the Yangtsze and partly irrigating the fertile district known as Kiang Peh or "North of the River."

In the beginning of the thirteenth century the old Yellow River, which then discharged into the Gulf of Pechili near the northern boundary of Shantung, burst its right bank, in the prefecture of Tung-chang-fu, in Shantung, and flowed through the level strait between eastern and western Shantung to Tsing Kiang-pu. Here it seems to have occupied the former channel of Hu-Hwei spoken of above. The time was one of political trouble in the Empire and the Yellow River was probably neglected; anyhow, after occupying this channel for about 80 years, a fresh breach, also of the right bank, occurred near Kaifung-fu, the capital of Honan. The waters submerged the same country as in 1888, and finally making their way to Tsing-Kiang-pu joined the former course and made their way to the sea past Hwai-an-fu.

As soon as the new course was put in some sort of order the possibility of occupying the portion of the former channel from near Tung-chang-fu to Tsing-Kiang-pu, as a canal, seems to have presented itself to the Emperors of the Mongol dynasty, then ruling at Peking. As there was not a sufficient supply of water, connections were made with the river Wan, flowing from the celebrated Tai-Shan, in Shantung, and the "I," which formerly flowed directly into the sea near Haichow, in the extreme north of Kiangsu. Both these rivers rise in the highlands and spread out in their lower levels into more or less shallow lakes, varying in extent according to the season. As the soil to be excavated—the bed of a post Tertiary sea—was a light sandy loam, and the lake lay close to the course of the channel, the work involved was of the simplest, mainly consisting of some masonry dams, still existing, which turned off the course of the streams. Rising in the highlands and having comparatively short courses, the water of these rivers is subject to sudden fluctuations, and, at times, the canal from Lung-Wang-miao, its summit level, to Tsing-Kiang-pu, is almost dry, while at times it is too full to be available for traffic. The bed falls considerably, and in order to surmount the difficulty and obtain water enough to float the boats making use of the canal, the Chinese engineers had recourse to probably the most primitive and ineffective expedient ever tried.

At intervals the banks of the stream were contracted and what are denominated "Ch'as" built; each of these consists of a masonry chamber 22 feet wide and from 150 to 200 feet long, grooved at the sides to permit of banks of wood being slipped down to form a dam. At ordinary times the canal is closed, but when the rice tribute boats arrive the sluices are drawn, and the boats are laboriously towed through the sluice, a couple of hundred men working with rude capstans, being frequently required to pass each boat, an operation involving from half an hour to an hour. Owing to the waste of water involved in this operation only a few boats can pass at a charge; the remainder have to wait till the dam is replaced and the upper reach filled with water to a sufficient height. In consequence of these delays the boats bearing the rice tribute starting from Tsing-Kiang-pu, in the early spring, do not arrive at the summit level, at Lung-wang-miao, till the middle of June, their average day's work varying from 7 to 11 miles.

From Lung-Wang-miao northwards to its junction with the Wei at Liu-Tsing-chow, the canal is wholly artificial. The soil here is a light loamy sand, and with the exception of a slight slope of about 15 inches in the mile towards the Gulf of Pechili the surface is practically level. In selecting Liu-Tsing as the point of junction the Chinese engineers,

with no knowledge of leveling beyond the flow of water in a ditch, adopted too low a point, and when the canal was made the numerous "Oh'as" became apparently a source of trouble. The canal here consists merely of a ditch 34 feet wide at the water level, and when full about 5 feet deep. As no permanent stream flowed through this district, the canal was supplied from the Wan at the summit level at Lung-Wang-miao, but the supply being intermittent and the southern portion with its wasteful system of haulage requiring the entire supply, the northern could only be accommodated intermittently.

As soon, then, as the rice tribute boats arrived at Sung-wun-miao the southern sluices were closed and the water diverted into the northern. The gradient along the line adopted was found inconvenient, while, owing to the destruction of forests in Shantung during the present dynasty, the supply had gradually dwindled down. The Chinese, to overcome the difficulty, adopted a still more extraordinary expedient, and deliberately set to to convert the channel, never very straight, into a series of the most extraordinary serpentine bends, in some places increasing the distance between points in the proportion of 3 to 1, and on the whole distance, carefully measured, by 8 to 5. Even with this the difficulties of navigation were so serious that after the rice-tribute junks were flushed through, the canal was closed for the remainder of the year. More serious evils to the country followed from the disturbance of the water ways, and as no culverts of discharge from west to east were ever formed the country lying west of the embankment was converted, in a great measure, into a swamp.

From Liu-Tsing onwards as the boats passed along the natural water ways of the Wei and the Peiho no alterations of any sort were effected till Tungchow was reached. From this place to Peking a small river was utilized, but in the same rude and ineffective way as before, and the rice transferred to small boats was simply hauled up the inclines.

The rice which left Tsing Kiang in April did not reach Peking till September, crews of 50 to 60 men being required to haul by main force the cargoes of from 100 to 150 tons with which the junks had originally been freighted.

This was the state of affairs prior to 1854, when the Yellow River again burst its bank, this time on the left, and resumed approximately its former course to the Gulf of Pechili. The new stream cut in two the canal between Tung-chang-fu and Lung-wang-miao, and for many miles obliterated all vestiges of its course. Of late years, by dint of great but unskilled labor, a connection has again been opened, but at present the difficulty between the Yellow and Wei Rivers is caused by excess rather than want of water. Enormous embankments of loam and kaoliang reeds have been formed to prevent the entrances of the river waters, and these are at ordinary times closed by dams of the same materials. On the arrival of the rice tribute fleet about the end of June, these are temporarily removed, and the boats carried in by the flush of the stream to find their way down the incline to Liu-tsing. So overcharged with silt is the stream of the Hoang-ho that the operation of floating the junks northward and back again in the autumn causes an annual silting up of the bed to a height of from 3 feet or upwards near Tung-chang-fu to a foot or less near Liu-tsing, and this deposit has each year to be dug out before a boat can pass.

Looked at from an engineering point of view the whole of the canal from Tsing-Kiang-pu to Liu-tsing, must be considered as not worth criticism while economically it is a serious burden on the resources of the empire. Had it ever been made use of for any commercial purpose

the State might have derived some benefit, though at an exaggerated cost, but so bad were the arrangements that it never was utilized for purposes of trade and no local traffic ever existed along it.

From Chin Kiang to Canton, the country is low and level and watered by innumerable lakes and small streams. These have been connected by channels cut at different times, during the last 3 or 4 centuries, and which form an almost complete water way, available during 6 or 7 months of the year, from Peking to Canton.

Upon this portion of the water way the traffic is very great, as it is upon the grand canal from Chin Kiang to Yaugchow.

There are no statistics obtainable of the cost of any of this work, the annual expense of its repairs, or of the traffic.

A. C. JONES,
Consul.

UNITED STATES CONSULATE,
Chin Kiang, November 4, 1889.

AUSTRALASIA.

NEW SOUTH WALES.

REPORT BY CONSUL GRIFFIN, OF SYDNEY.

The colony of New South Wales, although comprising an area of 310,700 square miles, contains barely 1,100,000 inhabitants, and it can not be expected for so limited a number of people to find the capital required to develop such capabilities for canalization as undoubtedly exist within this vast extent of territory.

My reports to the Department of State dated 1st and 30th of October, on irrigation and the reclamation of arid lands, will show how little has been done even to conserve water for pastoral and agricultural purposes. The New South Wales Government has now taken up this subject very energetically, and large sums of money have been appropriated to carry on necessary irrigation works; and it may be expected that in a very short period a number of irrigation canals will be under course of construction, to be followed, doubtless, by others for navigation purposes. The Government for a considerable period has been aware of the great advantages to be derived from such canals, but as yet the only sums expended for navigation have been to clear the rivers from snags and other obstructions. The sum of £80,000 (\$389,320) has been expended in this manner for improvements on the River Darling, and considerable more than that amount on the River Murrumbidgee.

I learn from information supplied to me by Mr. H. G. McKinney, Government engineer for water conservation, that the improvements on the Murray River have been mainly dealt with by the neighboring colonies of Victoria and South Australia, the boundaries of which are formed in part by that river. The riparian owners and occupiers of land along its banks, while admitting that the work has been of benefit to navigation, are said to be very decided in the opinion that their land has suffered great injury, for the reason that the removal of the obstructions occasions a free flow of water, and at the same time reduces the level of the surface of the water so that in time of flood only a more limited area of land can be benefited by the overflow. It is not desired that this state of affairs should continue, but that some method of irrigation should be adopted which would not interfere with improvements for navigation.

At Shoalhaven, to the south of Sydney, a short canal was cut by private enterprise to improve the navigation of the river of the same name which flows through that district, but it can hardly be regarded in any sense as a canal, but as a mere cutting to improve and change the flow of the river. A number of cuttings in rivers have been made by private enterprise in various parts of the colony for irrigation purposes, the most important of which distribute the flood waters of the River Darling. These cuttings vary from 6 to 14 feet in width; as the country in that district slopes gradually from the banks of the river the

land is flooded by gravitation. On all the more important rivers in the western district irrigation is carried on by pumping and for this purpose centrifugal pumps are used almost exclusively. The engines for working them vary from 8 to 10 horse-power and at one place the engines used are of 80 horse-power. In nearly all cases the water is distributed in earthen channels excavated with ploughs and scoops.

Mr. McKinney, in one of his reports, that on the Riverina district, directs attention to the canals in India, where he had large experience. He says, when dealing with the question as to the value of water and the area which could be irrigated by the available supply from the Murray and Murrumbidgee Rivers:

There is another way in which the supply now proposed to be utilized may be valued, and that is by estimating the extent of land which the supply would irrigate. In the first report of the commission it is mentioned that on the Eastern Juma Canal a flow of 1 cubic foot per second irrigates 250 acres, and that the same quantity of water from the Gauges Canal irrigates 240 acres. In these cases the management of the water is conducted on systematic and economical principles. I may here remark, and it can not be too often repeated, that it is to India, and not to America, that we must look for information regarding the details of irrigation management. As the table on this subject in the first report of the commission clearly shows, India is greatly in advance of other countries, and after it comes Spain, Italy, France, and America, in the order named. It is not probable that in this country we shall, for some time at least, attain to the Indian standard in economy of water; but as there will be no crops in Riverina which will require such a large proportion of water as sugar-cane and rice, which are common crops in Upper India, I think it may safely be assumed that here 1 cubic foot per second will irrigate 200 acres. Hence in the case of the Murray, I estimated that in the spring months the available supply is capable of irrigating 600,000 acres, and during the remainder of the year 200,000 acres in addition. In the case of the Murrumbidgee the question is complicated by the short duration of the high supply, and by the use of Lake Urana as a storage reservoir. It will, however, be safe, under any circumstances, to take the average irrigating capacity of the available supply at 400,000 acres during the spring, and at 150,000 acres during the remainder of the year. These figures give 1,350,000 acres as the area which the available supply in the two rivers is capable of irrigating. But a portion of the supply will be used for filling tanks and for other purposes besides irrigation, and another portion will be lost or wasted. A deduction of 20 per cent. will make ample allowance for these items, and will leave the net area of irrigation at 1,080,000 acres. The rates which landholders in this colony have stated their willingness to pay for water for irrigation vary from 10s. (\$2.44) to £1 (4.87) per acre. Judging from the known increase due to irrigation of various crops, even the higher rate would be very favorable to the landholder.

One of the projects which seems to have attracted attention, is that known as the Murrumbidgee Southern Canal System. In support of this project Mr. McKinney says:

The "summer level" of the Murrumbidgee at Wagga Wagga is 562 feet above Sydney high-water mark, and the proposed weir site, which is about 12½ miles by river below Wagga Wagga, may safely be taken at 550. The best reduced level for the bed of the canal at the off-take would depend on several circumstances, but it must be about 548—so near that level, in fact, that no difference which can occur in regard to it will affect my conclusions.

Taking 1 foot 6 inches per mile, the reduced level of the canal bed at 32 miles, where the Urana Branch will take off, will be 500. At 56 miles the main canal will cross the line of the Narrandera-Jerilderio Railway, and if the same rate of fall be continued, its reduced level at the crossing will be 464, which is a suitable level for crossing under the railway, at about 14 miles from Narrandera. From 56 miles to the head of the Conargo Branch, at 77 miles, the fall would continue at the rate of 18 inches per mile, and the reduced level at the latter place would be 432.5. From the head of the Conargo Branch to the head of the Wangonilla Branch, at 105 miles, the fall would be at the rate of 2 feet per mile, and the reduced level at the latter distance would be 376.5. From the head of the Wangonilla Branch, at 105 miles, to 129 miles, the fall will be at the rate of 2 feet per mile, and the height at the latter place will be 328.5. From 129 miles to the end of the canal, at 186 miles, the fall will be at the rate of 18 inches per mile, giving 243 as the reduced level of the canal bed at the tail.

Comparing these levels with others actually known, we find (1) that a suitable place can easily be found for crossing the Narrandera-Jerilderio Railway; (2) that

at 80 miles the reduced level of the canal bed would be 428 feet, while that of the ground on the railway line on the opposite side of the Murrumbidgee is 431 feet; (3) that the reduced level at 115 miles will be 358, while that at a point much nearer the river on the opposite side is 351; and (4) that at 150 miles which is nearly opposite to Hay, the proposed reduced level is 298, while that of the ground at Hay is 304. While, therefore, the positions of the various canals and branches are given only as good approximations, it is evident both from the figures given and from a study of the configuration of the country that both the positions shown for the canals and the rates of slope stated can in the main be adhered to.

The length of the Urana Branch will be about 35 miles, and taking the rate of fall at 18 inches per mile, the reduced level at Lake Urana will be 447.5 feet, that is, 87½ feet higher than the ground level at Jerilderie. The distance in a direct line from Lake Urana to Jerilderie is only 23 miles. It is at once evident from these figures and from the known uniformity of the district that the practicability of irrigating the plains between Lake Urana and Jerilderie direct from the Urana branch of the Murrumbidgee Southern Canal is beyond question; but an important point to be determined is whether this can be effected indirectly by using Lake Urana as a storage reservoir and irrigating from it. Although I have not been able to obtain any record of levels of Lake Urana, still there is important evidence available on this subject, namely, that afforded by the action of the Cockatjedong and Colombo Creeks.

As a flow of 2,000 cubic feet per second will require 94½ days to fill the lake, I think the Urana branch should have not less than this discharging capacity. As I propose to have the southern system of canals on such a scale as to admit of the utilization of 1,000 cubic feet per second in addition to the supply contributed to Lake Urana, the details regarding the main southern canal and branches will be as follows:

Description.	Length.	Rate of fall per mile.	Side slopes.	Depth of water.	Calculated discharge.	Nature of section.
	Miles.	Feet.		Feet.		
Main canal from head to Urana branch.	82	1½	1½ to 1	8	3,019.4	Double trapezoid bed; width = 100 feet; berme width = 141 feet.
Urana branch.....	35	1½	1½ to 1	.....	2,004.6	Bed width = 62 feet; berme width = 106 feet.
Main canal from Urana branch to Conargo branch.	45	1½	1½ to 1	7	996.2	Trapezoidal bed width = 43 feet.
Conargo branch.....	61	.....	1 to 1	6	218.4	Trapezoidal bed width = 21 feet.
Main canal from Conargo branch to Wangonilla branch.	28	2	1 to 1	7	825.6	Trapezoidal bed width = 32 feet.
Wangonilla branch.....	56	1½	1½ to 1	6	302.4	Trapezoidal bed width = 15 feet.
Main canal from Wangonilla branch to 129 miles.	24	2	1½ to 1	6	354.6	Trapezoidal bed width = 15 feet.
Main canal from 129 miles to 156 miles.	27	1½	1 to 1	5	199	Trapezoidal bed width = 14 feet.
Main canal from 156 miles to end.	80	1½	1 to 1	5	110.4	Trapezoidal bed width = 8 feet.

The approximate estimate for the quantity and cost of the works in this system is as follows:

Description.	Excavation.			Cost of regulating works.	Cost of distributary Heads.	Cost of bridges.	Total cost.
	Quantity.	Rate per cubic yard.	Cost.				
	Cubic yds.	s. d.					
Headworks, half share.....				£11,500			£11,500
Main canal, first part as above.....	6,408,000	1 3	£400,500	11,000	£4,000	£12,000	£27,500
Urana branch.....	4,928,000	1 2	287,467	16,000	8,000	10,000	321,467
Urana Lake.....	200,000	1 6	15,000	12,000	5,000		82,000
Main canal, second part.....	3,295,600	1 2	192,243	10,000	8,000	5,500	215,743
Conargo branch.....	1,248,320	1 0	64,416	2,000	6,000	4,000	73,416
Main canal, third part.....	1,494,330	1 2	97,195		2,000	2,500	91,695
Wangonilla branch.....	1,676,960	1 2	91,989	2,500	5,000	4,000	103,489
Main canal, fourth part.....	675,840	1 2	39,424		1,500	1,500	42,424
Main canal, fifth part.....	501,600	1 0	25,080		2,000	2,000	53,375
Main canal, sixth part.....	381,300	1 0	19,067		1,000	1,000	20,067
Total for work.....							1,372,384

Cost of works, as above.....	£1, 372, 384
Surveys.....	10, 000
Contingencies (say).....	69, 616
Grand total.....	1, 452, 000

Mr. McKinney's plan for the construction of canals from the river Murray are upon a much more elaborate scale, and they seem to have met with the approval of the leading Victorian as well as New South Wales authorities. He proposes that the site for the headworks of the canal shall be at Bungowannah, about 7 miles from Albury, for the following reasons:

First. It is at the last range of hills, with only open plain country beyond, so that there would be no rock excavation and no difficult country to pass through. Second. The river valley is at this place moderate in width and bounded by hills. Third. The depth of cutting, so far as can be judged without a survey, would be comparatively slight from the outset. Fourth. That the greatest depth of cutting likely to be encountered will be under 20 feet, and that this will not extend to a distance of more than three-quarters of a mile. Fifth. That the maximum height of weir required to divert a permanent supply into the proposed canal will not be more than 10 or 11 feet—that is, about one-fourth of the height of the weir which is proposed to divert the supply for the Goulburn irrigation in Victoria.

According to the levels taken by the department of harbors and rivers, the fall in the surface of the river from Albury to Bungowannah is 13.24 feet. What has been termed "summer level" at Albury is 489.63 feet above Sydney high-water mark; so that the corresponding level of the river at Bungowannah is 476.39 feet. As it would be desirable to have the bed of the canal at the off-take considerably above the bed of the river, I propose 475 as the reduced level of the former. At about 20 miles from its head the canal will cross the surveyed line of the proposed railway from Culcairn to Corowa, the crossing place being about 36 miles from the former place and 13½ from the latter. The reduced level of the ground there is 464, and as the fall from the canal head to the off-take of the Jerilderie branch will be at the rate of 1 in 5,000, the canal at this railway crossing will be in 10 feet of cutting.

It need scarcely be stated that the detailed surveys and levels will show that in some cases it will be advantageous to deviate more or less from the lines shown, but I have little doubt that the general arrangement proposed for the distribution of the water will be found the most suitable. While I think that in any case it will be necessary for the Government to construct the main canal and its principal branches, the minor channels for the distribution of the water should be constructed under fixed regulations, and subject to Government approval by the persons using them. The approximate details of the main canal and its principal branches are as follows:

Description.	Slope of bed.	Bed width.	Side slopes.	Maximum depth of water.	Calculated discharge per second.	Reduced levels.		Lengths.
						Beginning of length.	End of length.	
Main canal from head to Jerilderie branch.....	1 in 5,000	Feet. 84	1½ to 1	Feet. 8	cu. ft. 2,005	475	422	Miles. 50
Jerilderie branch.....	1 in 2,750	15	1½ to 1	6	842	423	359	33
Main canal from Jerilderie branch to Tuppall branch....	1 in 3,333.3	64	1½ to 1	7	1,489	422	396	16
Tuppall branch.....	1 in 2,500	12	1½ to 1	6	303	396	331	31
Main canal from Tuppall branch to end, near Moulamein.....	1 in 3,333.3	42	1½ to 1	7	1,002	396	223	110

He proposes that the main canal shall skirt the base of the Jindera Hills for a distance of about two-thirds of a mile from the headwaters. The excavations he thinks will be light on account of the presence of a lagoon, extending for some distance along the proposed line of the canal. At about the distance named and within a quarter of a mile of Bungowannah Park the canal will enter a short length of deep cutting, probably the only deep cutting which will be required. Beyond this cutting the line will follow the margin of the land subject to floods, but keeping just outside it till the canal finally emerges on the open plains

within a few miles of Howlong. From the latter place to Coreen the direction of flow of surface water shows that a good rate of fall is available, and from Coreen westward the uniformity of the country is all that could be desired. Mr. McKinney anticipates that the country through which the canal passes will be covered with a network of distributaries which will carry the water to all parts of the district bounded on the south by the Murray and the Edward Rivers and on the north by the Billabong Creek.

The following are the estimated quantity and cost of the earthwork in the main canal and its branches :

Description.	Length.	Estimated mean depth of excavation.	Estimated quantities.	Rate per cubic yard.	Cost.	Remarks.
	<i>Miles.</i>	<i>Feet.</i>	<i>Cubic yds.</i>	<i>s. d.</i>		
Main canal, first length	20	12	4,787,200	1 6	£359,040	} The depths of excavation assumed are considerably more than will be required to afford material for the banks.
Main canal, second length	30	8	4,605,600	1 4	300,373	
Jerilderie branch	33	5	728,000	1 0	36,300	
Main canal, third length	16	6	1,370,500	1 3	85,656	
Tuppall branch	31	5	591,100	1 0	29,555	
Main canal, fourth length	110	6	6,582,400	1 2	383,973	
Totals	240		18,562,806		1,194,897	

In addition to the excavation, the principal works required will be the regulators at the heads of the various branches, as well as at the head of the main canal, the outlets to distributaries, and the bridges to provide for cross traffic. As the canals will, as far as possible, follow ridge lines, there will be very little cross drainage to provide for. I believe it will be found that the only places where any such provisions will be required will be in the first 10 miles of the main canal. Taking all these items, and also the escape channel into account, the approximate cost will be as follows:

Excavation of canal and branches	£1,195,000
Weir at Bungowannah	29,000
Regulator at main canal head	5,000
Three other regulators, at £5,000	15,000
Bridges, 40, averaging £300	12,000
Distributary heads, 30, at £500	15,000
Drainage culverts, 2, at £1,500	3,000
Excavation of escape channel—say 450,000 cubic yards	30,000
Cost of surveys	16,000
Compensation for land	25,000
Total	1,345,000
Add 5 per cent. for contingencies	67,250
Total estimated cost	1,412,250

Mr. McKinney, in reply to some interrogatories of mine on the subject of riparian rights, says:

No law dealing with water rights has yet been passed, though a comprehensive draft bill dealing with the matter was published in the first report of the water conservation commission. The dams which have been constructed on creeks throughout the colony, and on some of the rivers, are all existing on sufferance only, and it frequently happens that dams so constructed are cut through by persons who own or occupy land lower down the course of the creek or river.

CANALS FOR SYDNEY WATER SUPPLY.

The city of Sydney is supplied with water from a distance of 63 miles. It is brought from a height of 437 feet above the sea level, and is conducted through a series of tunnels and open canals to Prospect, 40 miles

from the source of supply. From the reservoir at Prospect the water is conducted through wrought and cast-iron pipes to Sydney. The following table shows the extent of tunnels and canals and the length of piping used in the work :

	Miles.
Tunnels	11½
Open canals	33½
Wrought-iron pipes, 8 feet, 7 feet 6 inches, and 6 feet diameter.....	5½
Cast-iron pipes, 48 inches and 42 inches diameter.....	11
Water surface of reservoir.....	1½
Total.....	63

I learn from the official report of the Sydney water-supply board that through the sandstone country, which extends for a distance of about 12 miles from the outlet of the cataract tunnel, the channel has been formed with straight or slightly battered walls. The depth from berme to bottom is 10 feet; the width, 12 feet 6 inches; the depth of water, 8 feet. The fall is at the rate of 1 foot 9 inches per mile. Where lining was necessary the walls were built of masonry set dry or on cement; from the termination of the sandstone country the canal is mainly through shale and clay. The dimensions are: Width at bottom, 5 feet; slope of sides, 1 to 1; depth from top of berme, 9 feet; top width, 23 feet; and width at top water level, 19 feet. The sides and bottom are protected with stone pitching 9 inches thick. The inclination of this channel is 2 feet per mile. The canal above Prospect terminates in a basin with an overflow weir, leading the water into a concrete channel down which it flows into the reservoir. The inclination of this channel is 1 in 38.25. The level of the overflow weir at the end of the canal is 243.15; that is, 48.15 feet above the high water of the reservoir. The following are the dimensions of the reservoir at Prospect:

Area of watershed, 2,361 acres; area of water surface, 1,261 acres; R. L. top of dam, 209 feet above high water, Sydney; high-water level, 195; lowest level to which water can be drawn for supply, 170; width of dam on top, 30 feet; slopes, 3 to 1 inside, 2½ to 1 outer, with 15-foot bermes at R. L. 175 and 147; width of by-wash, 100 feet; maximum height of dam, 84.77 feet; length, 110 chains; greatest depth of puddle trench, 50 feet at the deepest part of bank; puddle wall, width on top, 8 feet, side slopes 1 in 8; puddle trench side slopes, 1 in 8.

The water from the reservoir is drawn through a tunnel carried round the east end of the dam by means of two 48-inch iron pipes and delivered into the canal leading from the reservoir. A 30-inch main has been laid from the basin above the reservoir to the canal below it for the purpose of supplying the latter independently of the reservoir, and also to give head for the working valves. The 48-inch pipes referred to also serve for emptying the reservoir. The canal below the reservoir is 4½ miles long, and the cross section is partly with vertical walls and partly V-shaped. The high-water level at the reservoir end of the canal is 175.50. The level of the top of the canal is the same throughout the entire length of this section, viz, 177.50. This arrangement allows an increased head to be obtained for the works nearer Sydney. Owing to the nature of the ground, 900 feet of this section had to be covered in, and is virtually a culvert under pressure. The fall in canal is at the rate of 6 inches per mile. At the end of the canal a straining basin and pipe-head reservoir has been built. From this reservoir to Sydney the water will flow through pipes.

Mr. Coghlan, the Government statistician, states the cost of the works to the close of 1888 to be £2,499,970 (\$12,122,437). All the works, he states, with the exception of Prospect reservoir, are completed. The dam there is $1\frac{1}{2}$ miles long and 80 feet deep in the center, and contains 2,316,500 cubic yards of earthwork, and is raised to sufficient height to enable the canals leading to Sydney to be supplied.

The works for the supply of Sydney with water are on a scale far beyond the requirements of the present inhabitants, but on account of the rapidly increasing population it is exceedingly doubtful if the metropolitan water board, under whose control the works are administered; will grant water rights for irrigation purposes except on a limited scale. It may be mentioned that the Prospect reservoir has a present available capacity of seven thousand millions of gallons and a gross capacity of over ten thousand millions of gallons.

G. W. GRIFFIN,
Consul.

CONSULATE OF THE UNITED STATES,
Sydney, November 18, 1889.

CONTINENT OF EUROPE.

BELGIUM.

REPORT BY CONSUL PRESTON OF LIEGE.

Canals in Belgium are numerous; but thirty-one only merit special notice. They may be divided into two classes. The large canals having a depth and width sufficient to float the large sea going vessels; of this class there are four. Of the smaller canals, having a depth of not over 2 metres 20 centimetres, and which are destined only for the canal boats which navigate on the rivers, there are twenty-seven.

LARGE CANALS.

1. The canal from Ghent to Bruges, and from Bruges to Ostend, connecting with the North Sea. Its length is 67 kilometres. The part from Bruges to Ostend was constructed in 1822 and the whole work finished in 1825.

In 1885 the kilometric tonnage* was 14,837,258 tons, and the total amount transmitted 945,258 tons.

The maintaining of the works cost in 1886 100,605 francs and 2,862 francs for improvements. The tolls collected for the same year amounted to 33,673 francs.

2. The canal from Ghent to Terneuzen, which gives to Ghent the importance of a sea port. It ends at the Escaut maritime,† which passes near the town of Terneuzen. Its length is 20 kilometres. Its construction was begun in 1824 by a company and the government purchased it in 1827 as it was, and completed the second part in 1873, and the third part in 1878. The kilometric tonnage in 1885 was 12,486,157 tons; the total amount transported, 913,236 tons. In 1886 the maintaining of the work cost 152,220 francs, and for improvements, 9,995 francs. The tolls collected amounted to 21,097 francs.

3. The canal of Willebrœck, from Brussels to the River Rupel; it passes through the town of Vilvorde, the village of Willebrœck, and runs into the Rupel near the town of Boom, thus putting Brussels in communication with the Escaut and the sea. Its length is 28 kilometres. Its construction was begun in 1830 and finished in 1835. The kilometric tonnage in 1885 was 27,252,245 tons and the total amount transported was 1,074,585 tons.

4. The canal of Louvain. It commences at Louvain, passes by Malines, and ends at the river Rupel, thus being in communication with the Escaut and the sea. Its total length is 30 kilometres. It was completed in 1836. The kilometric tonnage in 1885 was 6,911,835 tons and the total amount transported 253,491 tons.

* By kilometric tonnage is meant each ton that is transported the distance of a kilometre.

† The river Escaut, called in Flemish the Schelde.

SMALL CANALS.

1. The canal from Charleroi to Brussels by Hal. It unites itself at Brussels to the canal of Willebroeck. It serves also for communication between the basin of the Escant and that of the Meuse. Length 74 kilometres.

This canal has its branches which are directed towards the coal basin of the center,* altogether in length 15 kilometres. They are now occupied in the construction of a canal which will put these branches in communication with the canal from Mans to Condé. These important works will give to this canal and its branches a larger section. It was begun in 1832, finished in 1839. Its kilometric tonnage is 30,158,356 tons; total amount transported 789,927 tons; cost of maintenance 131,888 francs, and for improvements 4,982 francs.

2. The canal from Plasschendaele to Nieuport, which leaves the canal from Bruges to Ostend and unites at Nieuport at the Yser and to the canal from Nieuport to Furnes. Its length is 21 kilometres. It was purchased by the Government in 1854. In 1885 its kilometric tonnage was 1,468,213 tons, the total amount transported 93,613 tons, the cost of maintaining 18,741 francs; and for improvements 6,000 francs; tolls 12,071 francs. This canal has divers branches; the canal of Oudenbourg, of Moerdyck, of Ghistells, and of Bourgogne; altogether 12 kilometres in length.

3. The canal from Nieuport to Furnes, which follows up to Dunkerque; its length is 10½ kilometres. It was purchased by the Government in 1854.

4. The canal of Basse Colm, which goes from Furnes to Berques, in France; length, 11 kilometres.

5. The canal of Lao, which begins at Furnes and rejoins the Yser at Lao; length, 15 kilometres. Kilometric tonnage in 1885, 235,115 tons. Total amount transported 17,775 tons.

6. The canal of Yopres to the Yser, continuing to Nieuport; length 15 kilometres. Kilometric tonnage, 299,761 tons. Total amount of tonnage transported; 20,425 tons.

7. The canal from Dixmude to Handzeame; length, 12½ kilometres. It has a branch towards Zarren, in length 3 kilometres.

8. The canal from Ypres to the Lys, ending near Wervicy, not yet finished; length, 14½ kilometres; commenced in 1846.

9. The canal from Roulers to the Lys; length, 16½ kilometres; begun in 1846, finished in 1853. Kilometric tonnage, 741,283 tons. Total amount transported, 55,329 tons. Cost of maintaining, 16,037 francs; tolls, 1,960 francs.

10. The canal of Schipdonck, or from Deynze to Heyst, which derives its water from the Lys. In its latter part it runs parallel to the canal Leopold. Its length is 54 kilometres.

11. The canal of the Liève, which commences at the canal from Ghent to Ortend, at about 5 kilometres from Ghent, and terminates at the canal of Schipdonck; length, 11 kilometres. Kilometric tonnage, 29,260 tons; total amount transported, 24,569 tons.

12. The canal from Bruges to the Ecluse, by Damme; length, 14 kilometres. Kilometric tonnage, 309,807 tons; total amount transported, 28,973 tons. The canals of Schipdonck and the canal Leopold pass in a tunnel under this canal.

*They call the basin of the center, the east of Mans, that part of the coal basin of the Hainaut, comprised between the Borinage and the basin of Charleroi; its limits are easily traced by the lines St. Denis, Harmigries, Fontaine l'Evêque, and Gouy-se-Piéton. Its extent is about 400 square kilometres, inclosing forty villages.

13. The canal of Lisseweghe commences at the canal from Bruges to Ostend, near Bruges, and runs towards the North Sea; length, 13 kilometres.

14. The canal of Blankenberghe, a branch of the canal from Bruges to Ostend; length, 12 kilometres. Commenced in 1873.

15. The canal Leopold or canal of Selzaete, which takes its waters from the northern part of the Flandres and ends in the sea at Heyst; length, 38½ kilometres. Commenced in 1854; finished in 1855.

16. The canal of Moervaert, which puts the Durme in connection with the canal of Terneuzen; length, 21 kilometres. Begun and finished in 1846. Kilometric tonnage, 1,169,573 tons; total amount transported, 126,420 tons. Tolls, 2,980 francs.

17. The canal of Langeleede, which begins at the canal of Moervaert and terminates near the frontiers of Netherlands; length, 5 kilometres. Kilometric tonnage, 37,039 tons; total amount transported, 65,890 tons.

18. The canal of Stekene, which takes its origin at the village of Stekene and terminates at the canal of Moervaert; length, 5 kilometres. Built in 1853. Kilometric tonnage, 194,930 tons. Total amount transported, 49,972 tons.

19. The canal from Liège to Maertricht commences at the river Meuse in Liège and terminates at Maertricht, where it again enters into the Meuse; length, 25½ kilometres, of which 20 kilometres are on Belgian territory. Commenced in 1845, and finished 1850. Kilometric tonnage, 10,382,932 tons (in 1885); total amount transported, 614,432 tons. Cost of maintaining, 120,318 francs; and for improvements, 25,597 francs. Tolls in 1886, 76,259 francs.

20. The canal from Maestricht to Bois-le-Duc, which forms a prolongation of the preceding canal. It traverses the province of Limbourg, in Belgium, over an extent of 45 kilometres. Begun in 1823, finished in 1826. Kilometric tonnage, 24,175,845 tons; total amount of transportation, 466,608 tons. Cost of maintaining, 60,093 francs, and for improvements, 6,117 francs. Tolls, 62,163 francs.

21. The canal of the junction of the Meuse and the Escaut, which starts from Bacholt (northwest of Maeseyck) at the canal of Maestricht to Bois-le-Duc, passing by Herenthals and terminating at the Escaut, at Antwerp. This canal connects with the Little Nèthe, a little under Herenthals. Length, 86 kilometres. It was commenced in 1843, part of it finished in 1844, and its branches from 1846 to 1856. One of its branches is towards the camp of Beverloo, in length 15 kilometres; another towards Hasselt, 39 kilometres, and a third towards Turnhout, 25 kilometres. The kilometric tonnage of the whole was, for 1885, 38,944,056 tons, and the total amount transported 995,604 tons. The cost of its maintenance was 125,330 francs and for improvements 26,745 francs. Tolls amounted in 1886 to 263,795 francs.

22. The canal from Turnhout towards Antwerp rejoins near Antwerp the canal of the junction. Length, 37 kilometres; finished in 1846. Kilometric tonnage, 3,552,777 tons; amount transported, 191,397 tons. Cost of maintenance, 17,725 francs. Amount of tolls in 1886, 21,191 francs.

23. The canal from Mans to Condé, uniting those two towns. Length 24½ kilometres. It was purchased by the Government in 1843. Its kilometric tonnage in 1885 was 8,364,433 tons; the total amount transported, 1,062,385 tons. Cost of maintenance 28,950 francs, and for improvement 9,881 francs. Tolls in 1886, 88,215 francs.

24. The canal from Pommerœul to Antoing, which connects the canal

of Mans with the Escaut without passing into France. Length 25 kilometres. It was finished in 1826 and purchased by the Government in 1828. For 1885 the kilometric tonnage was 10,840,589 tons; the amount transported 742,742 tons. Cost of maintenance 30,694 francs, and for improvements 2,803 francs. Tolls in 1886, 82,583 francs.

25. The canal from Blaton to Ath; length $21\frac{1}{2}$ kilometres, and the river Dendre canalized from Ath to Termande, length 65 kilometres, which puts the canal of Pommerœul to Antoing, and that of Mans to Condé in communication with the lower Escaut. It was purchased by the Government in 1840 and then sold to a company in 1867. In 1885 its kilometric tonnage was 8,912,094 tons, and the amount transported 418,649 tons. Expense of maintenance 7,540 francs.

26. The canal of Espierres, which commences at the Escaut near the limit of Hainaut and western Flanders and goes towards Roubaix 8 kilometres; commenced in 1841, finished in 1842. The kilometric tonnage for 1885 was 421,993 tons; the total amount transported 61,495 tons.

27. The canal from Bassuyt to Courtrai which joins the Escaut to the Lys; length, $15\frac{1}{2}$ kilometres; commenced in 1858, finished in 1863. In 1885 the kilometric tonnage was 1,019,848 tons; the total amount transported 71,237 tons. Cost of maintenance 7,540 francs.

IRRIGATING CANALS.

There are besides the above numerous small canals for purposes of irrigation, but these are of little consequence, the natural streams and rivulets answering the same purpose; besides, there is so much rain in this country that artificial irrigation is almost unnecessary.

LENGTH AND OWNERSHIP.

In 1885 the total length of all the canals in Belgium was 1,651 kilometres, 600 metres. Part of them are the property of the Government, which has built and maintains them; on these canals navigation is generally free. Some others belong to the province or to the communes and the rest to large companies. In every case these companies are chartered by the Government, which also gives subsidies for the construction and maintaining of them.

EXPENSES.

The expenses to the Government for the canals are of two kinds: First, ordinary expenses for their maintenance. In 1884 these amounted to 2,064,819 francs; in 1885 to 1,792,431 francs, and for improvements in 1884 378,640 francs, and in 1885 287,056 francs. Second, the extraordinary expenses, such as new constructions, extraordinary repairs, canalization of rivers, etc., which are sometimes very important. Thus in 1883 the ordinary expenses were 2,237,635.46 francs, and the extraordinary expenses provided for by special decree were 11,956,487.49 francs.

The following table gives the ordinary expenses from 1880 to 1885. In some years they have included improvements in ordinary expenses.

	Francs.
1880.....	4,986,961.00
1881.....	8,339,635.90
1882.....	11,464,723.16
1883.....	2,237,635.46
1884.....	2,064,819.00
1885.....	1,792,431.00

TOLLS.

The amount of tolls collected varies a great deal; some canals are entirely free, on others the toll is collected by the kilometric ton, the lowest toll being .0012 of 1 franc or .12 of a centime per kilometric ton. There are some on which the toll is 1 franc per ton for the whole canal, or a certain fee, sometimes as much as 1 franc by the vessel, for passing the locks.

EFFECT ON CHEAPENING TRANSPORTATION.

It seems almost unnecessary to remark in conclusion that Belgium takes the lead on the continent of Europe, in establishing these artificial water ways, and that to that fact is owing, in a great measure, her commercial prosperity. Nothing contributes so much to the commerce of any country as rapid, easy, and cheap means of communication, and the experience of the Belgians has been like that of the United States, that canals have done more than anything else, in the last 50 years, to cheapen transportation.

WM. S. PRESTON,
Consul.

UNITED STATES CONSULATE,
Liège, September 25, 1889.

ANTWERP.

REPORT BY CONSUL STEUART.

MEUSE-SCHELDT CANAL.

History.—A project was formed in 1626 to join by a canal the river Scheldt to the Rivers Meuse and Rhine; the details upon its course are wanting, but we know Venlo was the point of leaving the Meuse. The work was suspended in 1628, the Dutch having become masters of the two extremes of the line.

In 1805 Napoleon decided that this important communication should be opened; the preparations commenced immediately, and in 1808 work was being done upon nearly the whole length of the line. Soon, however, the reunion of Holland to the French Empire, and political events, interfered, and the work between the Meuse and the Rhine, already well advanced, was for the second time abandoned. The building of this canal would have increased the importance of the port of Antwerp, and the transit towards Germany, but after the revolution of 1830, the execution of the project, such as originally intended, had no longer the same interest for Belgium, as Venlo, the point of passage to the Meuse, remained in Holland.

In October, 1838, Chief Engineer Kümmer resumed the studies upon this matter and presented a complete plan of canalization comprising the opening of the following canals, viz:

1. A first section of the canal from the junction of the Meuse with the Scheldt, from Bocholt to Pierre Bleue.
2. A second section from Pierre Bleue to Herenthals, where a junction is made with the Scheldt by the river Petite Nèthe canalized.
3. A section from Pierre Bleue to Hasselt, where a junction is made with the river Demer.

4. A section from Pierre Bleue to Antwerp by Turnhout.

A law was passed in 1843 permitting the Government to put in execution a part of the works mentioned in the project presented by Eugène Kümmer.

This law stipulated that the canal to be made for the junction of river Rupel to the canal of Bois le Duc should be composed of two sections, namely from Bochoit to Pierre Bleue, and from Pierre Bleue to Herenthals.

The first section, from Bochoit to Pierre Blue, is entirely in the province of Limbourg, the work was adjudged in January, 1843, and the canal was opened for navigation the 22d of August, 1844.

The second section, from Pierre Bleue to Herenthals, of which the work had been given out in August, 1844, was opened to navigation the 21st of September, 1846.

The third and last section was finished in 1856, but it was only in 1859 that the direct junction of the Meuse with the Scheldt was made by bringing the maritime sluice of the Kattendyck, at Antwerp, into service. Before this period the canal arrived only to the Pettie Nèthe, a little below Herenthals, and the junction was made with the Scheldt by the rivers Nèthe and Rupel.

The first two sections had been constructed at first with 6 metres of width and 1.65 metres depth of water; the necessary work of their enlargement was terminated in 1862, and to-day the entire course, with 10 metres width and 2.1 meters depth of water, present the same conditions for navigation as the lateral canal of the Meuse from Liege to Maestricht and that from Maestricht to Bois le Duc.

In 1872 the development of the commerce of Antwerp necessitated the enlargement of the port; a part of the third section of the through canal, 817.30 metres in length, was incorporated with the new docks or basins, constructed at that time, in such a manner that the sluice by which the canal emptied before at the Kattendyck basin was removed and was made part of the basin of the canal, at the expense of the city of Antwerp.

Description.—The total length is 86,354 metres; of this, 27,282.60 metres run through the province of Limbourg, and the rest, 59,071.40 metres, is within the province of Antwerp. The width is generally 10 metres, except in the stations or basins and at the origin of the canal, where it is 20 metres, and comes gradually back in a course of 285 metres to 10 metres again.

The interior slopes present generally an incline of from 3 at the base to 2 at the top.

The embankments are 4 metres wide at the crown and have a transversal inclination of .10 metres.

Where the embankments are elevated they are generally bordered by a counter embankment and a counter ditch, varying in width and depth.

Where the embankments are low they are bordered by a counter ditch of 0.90 metre width and 0.30 metre depth, having a slope of 45 degrees.

The exterior slopes of the embankments and counter embankments run down to the natural cultivable land.

The towpaths upon both banks are, for the greater part of their distance, covered with gravel to the width of about 1.50 metres.

Water supply.—The net work of the canals of the Campine is fed by the waters of the river Meuse; the double flood gates for taking the water at Bochoit serve for the supply of the canal. The waters are taken from the Meuse at Hocht. The third section of the canal is, dur-

ing a great part of the year, supplied at Grobbendonck by water taken from the Nèthe when this river can give an abundance of water. When the flow diminishes, the second section of the canal furnishes the necessary quantity. Finally, when the Nèthe needs all its water in order to maintain its low water mark, the concession of water is shut off at Grobbendonck.

Rights of navigation.—The royal decree of July, 1865, regulates the management and the tolls of the navigable waterways administered by the state. It fixes the tax of navigation at .0075 franc per ton and per kilometre.

All fractions below .50 of a ton are not considered, and all over are counted as a ton.

All distance less than a kilometre is paid by reason of that distance.

No toll is collected upon boats passing empty, but the boatmen must, in this case, provide themselves with a permit of circulation, which is given to them upon their demand by the receiver of tolls, against a payment of 20 centimes.

Under an order of the minister of finance in 1866, boats for manure, either loaded or empty, whatever be the quantity they carry, enjoy an entire exemption from all tolls, and have permission to circulate empty.

A royal order of 1867 decrees that rafts and cargoes of wood shall be subjected to the toll fixed by the royal decree of 1865, in counting a meter cube for a ton.

A royal decree of February, 1865, established a minimum tax of 20 centimes to replace any inferior charge to which the boats are submitted by reason of their cargo or distance traveled.

Supervision—Bureaus to the number of 7 are established, viz :

No.	Bureau at—	Location.	Distance.
			Kilometres.
1	Bochoit	Beginning of canal	
2	Bridge No. 8	Neerpelt	12. 309
3	Gate No. 1.	Pierre Bleue	26. 795
4	Gate No. 4	Dosschel	31. 050
5	Gate No. 8	Gheel	43. 819
6	Gate No. 11	Herenthals	54. 256
7	Gate No. 14	Wyneghem	74. 892

Locomotion.—The boats are either drawn by horses or men. The last-named method is employed only for the small boats of 50 to 70 tons. The towage by steam is rare; ordinarily the steam towboats are themselves boats carrying cargo.

On several occasions attempts have been made to use boats, specially constructed, as towers, but they have been discontinued.

The towage is paid generally by the day and sometimes by the ton of cargo. The day costs 10 francs for man and horse and 2.5 francs for a man. The contracts which are made for the towing by the ton give an average of francs .007 for going up and francs .0035 for descending, per ton and kilometre.

Boats.—The draft of water of the boats which navigate the canal of the junction of the Meuse with the Scheldt is at the most 1.90 metres, but it comes down to 1 metre and sometimes less; their tonnage is variable; exceptionally it reaches 300 and even 330 tons.

The boats that traverse the canal can, in point of tonnage, be ranged in three classes, the first measuring 200 tons, the second 130 to 140, and the third from 60 to 80 tons.

The length and breadth of the boats varies considerably; the longest

are not 50 metres, their breadth is often over 5 metres, and sometimes more than 6.

All the boats navigating the canal have the movable mast.

The navigation by steam is very small, say an average of five or six steamers per month, making the voyage from Liege to Antwerp and *vice versa*.

Telegraph.—A telegraphic line for the service of the management of the water is established along the canal from Bocholt to Antwerp.

Character of freight.—The ordinary transports are as follows:

1. Pine wood, sent towards the coal mines of Belgium and France, and fire wood for the interior.
2. Coal from the neighborhood of Liege sent towards Antwerp and Limbourg.
3. Material for building—bricks, rough, polished, and paving stones, marble and slate.
4. Manufactures of iron, rails, beams, etc., coming from the factories of the province of Liege, and sent principally towards Antwerp.
5. Hay coming from the irrigated grounds along the canal, sent to the interior of the country.
6. Minerals of iron, lead, zinc, and copper, sent from Antwerp to Liege.
7. Pine wood and American oak, loaded at Antwerp and sent to Liege.
8. Grain, wheat, rye, oats, and barley, coming from abroad and sent from Antwerp towards Liege.
9. White sand for glass works, taken from along the banks of the Canal de la Campine and the branch towards Hasselt.

TURNHOUT-ANTWERP CANAL.

Description.—The canal from Turnhout to Antwerp is the extension, towards the latter city, of the branch canal towards Turnhout. Its course follows the line of the river Scheldt to Saint Leonard; from this point it bends towards the south and joins a little less than 7 kilometres from Antwerp, at the sixteenth sluice, the canal of junction between the Meuse and the Scheldt.

The first section reaching to Saint Leonard was opened to circulation in 1866, and the second and last in 1874.

The canal has a total development of 37,332 metres. It was constructed in the first instance on a liberal scale, and presents a width of 10 metres. The anchorage in the first dam of the canal is only 1.65 metres, because this dam joins to the branch canal to Turnhout, which has itself only 1.65 metres of anchorage; further on, at the gate No. 1, the anchorage is 2.10 meters, as in the canal of the junction of the Meuse to the Scheldt.

The canal from Turnhout to Antwerp was destined in the main to benefit the industries of the city of Turnhout; it has given origin to a number of manufactories of ceramics, of which the importance is constantly increasing.

The management of the canal is regulated by the royal order of the 25th November, 1844, which has received modifications and additions, made applicable to the first section by royal order of November, 1865, and to the second section by that of November, 1874.

Tolls.—The taxes on navigation in the first section are fixed by royal decree of November, 1865, for the boats loaded and empty, and by that of September, 1867, for the rafts and cargoes of wood; the one, .0075

franc per ton and kilometre, or per metre cube and kilometre for the wood. The manure is exempt from all tax, but the empty boats are submitted to a tax of 20 centimes. The same charges have been laid upon the second section by a royal decree, made applicable in November, 1874.

Bureaus of collection.—The first bureau is at the origin at Turnhout, a second is established at bridge No. 9 at Saint Leonard, and a third, a bureau of control, at bridge No. 15 at Schooten, at the junction of the second section of the canal of Turnhout with the third section of the canal of junction of the Meuse with the Scheldt.

Towage.—The towage is made by sail, by men, or by horses; in the last case payment is made by the day. A horse with its conductor costs 10 francs, and the salary of men is from 2 to 3 francs per day. If one calculates the cost price by ton-kilometer, the towage will be found to cost about .0065 francs when a horse is used, and .00165 francs when the work is done entirely by men.

Boats.—The maximum tonnage is 172 tons between the origin and gate No. 1; the boats have generally from 20 to 30 metres of length, with three metres of width. Between Ryckevorsel and the end the tonnage can be estimated at about 300 tons, and the ordinary dimensions of the boats for this section vary from 30 to 40 metres in length, with 3 to 5 metres of width.

Telegraph.—A telegraph line established along the canal is utilized for the service of navigation and management of the water.

KIND OF TRANSPORTS.

Freight.—The merchandise transported is generally wood, coal, and ceramic products.

JOHN H. STEUART,
Consul.

UNITED STATES CONSULATE.
Antwerp, December 6, 1889.

BRABANT, HAINAUT, AND NAMUR.

REPORT BY CONSUL ROOSEVELT, OF BRUSSELS.

There are no canals in the provinces of Brabant, Hainaut, or Namur used for irrigating purposes.

The establishing of canals has cheapened transportation in some localities, while in others no material change has been produced.

BLATON CANAL.

This canal is constructed on the plan known here as "point à partage," or dividing point, which consists of a reach 5 994 metres in length and two branches, one having a development of 3,876 metres, and ten locks, having total height of 29 metres; the other a development of 11,723 metres, eleven locks, and total height of 33 metres. Length between locks, 48 meters. There are double lateral reservoirs for the purpose of economizing one-half the quantity of water necessary to flood the locks, but owing to imperfect construction they are unsatisfactory.

Water gauge.—The normal height is fixed at 7 feet to accommodate vessels drawing 6 feet.

Water supply.—The locks are supplied by means of three machines, which, in conjunction, force from 25,000 to 30,000 cubic meters of water in twenty-four hours.

Navigation tax.—Per ton, 24 centimes; per ton capacity of boat, 8 centimes; per ton capacity of boat without cargo, 0; total, 32 centimes.

Description.—Total length of canal, 21,593 metres; width of ordinary basin at bottom, 11 metres; number of locks, 21; average length of locks, 41 metres; average depth of same, 1 metre 90 centimetres. The locks are mostly constructed of rough stone. Time required to pass through locks thirty-one minutes. The canal is furnished with 12 permanent, 16 draw, and 3 turn bridges, of which 4 are of masonry, 4 of iron, 4 of iron and brick, 2 of cast-iron, and 17 of wood construction. Navigable width of 5 metres 20 centimetres. Height varies from 3 metres 64 centimetres to 4 metres 40 centimetres; width of tow path, 3 to 4 metres.

BRUSSELS CANAL.

The Brussels Canal to Rupel, also called the "Willebroeck," is the oldest canal in Belgium and one of the most ancient in Europe. It was begun in 1550 and finished in 1561. The construction was executed principally by the city of Brussels, in consequence of grants from Marie of Bourgogne, June 4, 1477, and Charles V, November 7, 1531. The bottom of the original canal measured only 10 metres in width, with an anchorage varying from 1 metre 80 centimetres to 2 metres.

From 1829 to 1835 the canal was enlarged and deepened to its present dimensions. In 1886 a proposition was submitted to the legislative body then in session at Brussels having for its end the enlarging of the canal to such dimensions as to virtually make Brussels a seaport. Recently a public meeting was held in this city relative to the same subject, and urging the Government to at once begin work on the canal. It is now thought that within the course of 2 or 3 years the canal will be so enlarged and improved that sea-going vessels of large tonnage may load and unload at the docks of Brussels.

Water supply.—The canal is supplied from the river Senne.

Towing.—Towing is performed by sunken chains. There are five trains ascending and a like number descending daily, each train having in tow from six to twelve boats.

Wharves.—Properly speaking, there are no wharves, excepting at Brussels. The boats may, however, load and unload along the route at localities indicated by the agents at Brussels.

Boats.—Boats or vessels with cargo are divided into three classes, and taxed by the ton and cubic metre, at 6 centimes for the first class, 4½ centimes for the second class, and 2 centimes for the third class. Fixed rates for the entire route are as follows:

Prices for the trip, including services of locks and stopping points.

Nature of vessels.	To go and return—	
	With or without cargo.	With cargo.
	<i>Francs.</i>	<i>Francs.</i>
Charleroi boats	16	20. 50
Tournai boats	27	37
Ocean vessels	29	60
Beurtsmans	20	26
Small craft and garden boats	9	16
Boats transporting manure and farm refuse*	13. 75	13. 75

* 15 per cent. reduction.

Nature of transports.—Coal, bricks, stones, tiles, and wood.

Description.—Total length, 28,129 metres; number of locks, 5, varying in length from 30 to 76 metres; average width, 15 metres; anchorage, 3 metres 20 centimetres. The locks, with one exception, are constructed of stone. Time of passage through locks, from 30 to 45 minutes. The canal is furnished with a towpath varying in width from 4 to 8 metres. There are 17 bridges, of which 10 are turn and 7 draw bridges; 4 are constructed of cast iron, 8 of wood, 3 of iron, and 2 of steel. The navigable passage, from 7 metres 50 centimetres to 8 metres 50 centimetres.

Charleroi Canal.—As early as 1570 the cities of Brussels, Malines, Louvain, and Antwerp united in fruitless efforts to induce the Government to extend the Brussels Canal to Charleroi. At various times thereafter the question of extension was agitated, by the city of Brussels in 1660, the Austrian Government in 1750, 1784, and 1788, and finally by the Netherlands, April 2, 1827, when work was begun, and on September 22, 1832, the improved and extended canal, which to-day is recognized as one of the most valuable water ways of the Kingdom, rendering immense service to commerce and industry, was opened to traffic.

Towing.—Towing is performed by horses. On the branch canals it is generally done by the boatmen; consequently no tax is exacted.

BOATS.

Maximum tonnage of boats frequenting part of canal at long sections.....	tons..	279
Ordinary length (rudder not included)	metres..	35
Ordinary width	do....	5
Maximum tonnage of boats frequenting part of canal at short sections.....	tons..	72
Ordinary length	metres..	20
Ordinary width	do....	2½

Nature of transports.—Coal, iron ore, cast iron, and paving stones.

Description.—Total length, 75,289 metres; number of locks, 55, varying in length from 19 to 40 metres; average width of locks, 10 metres; plan of construction, vertical walls of brick with chains covered by free-stone; length of time necessary to pass through locks, from 7 to 25 minutes; anchorage, 2 metres; width of towpath, from 3 to 4 metres; number of bridges, 77, of which 57 are permanent, 16 draw, and 4 turn bridges, 13 are of iron, 33 of masonry, 18 of wood, 3 of iron and brick, and 10 of iron and wood; width of navigable passage, varying from 1 metre 85 centimetres to 28 metres.

Navigation tax.—The tax is fixed at five-tenths of a centime per ton.

Meuse Canal.—January 1, 1879, the sum of 22,818.84 francs was appropriated by the Belgian Government for the canalization of the Meuse River from the French frontier to Visé.

BOATS.

Maximum tonnage	tons.	300
Maximum length	metres.	41
Maximum width	do....	5
Depth	do....	1.80

Towing.—Towing is performed by propeller steam tugs and by horses.

Navigation tax.—The tax is fixed at four-fifths of a centime for each 5 kilometres and by cubic metre capacity. No exception is made for lumber boats or rafts. The tax is paid at the collection office by the arriving and departing boat according to the cargo mentioned in the documents indicating the capacity of the boat or cubic metres contained

in wood float; empty boats at half rates. When the cargo of a boat does not exceed the half of its tonnage the tax is reduced two-fifths of a centime, which is collected as cargo tax, and four-fifths of a centime as boat tax. When the cargo exceeds this quota the entire tax is collected on the total tonnage.

Nature of transports.—Going into France, coal. Returning from France, lumber, poles, bark for tanning purposes, iron ore, salt, slate, and white stone. Going into Holland, large quantities of building stones, finished and in the rough, and cast-iron. Returning from Holland, ore, grain, and wood.

Description.—Total length from French frontier to Visé, 26,575 meters; number of locks, 24, varying in length from 50 to 100 metres, and in width from 7 to 15 metres; anchorage, 2 metres 10 centimetres. Time necessary to pass lock, from 10 to 25 minutes. Twenty-five permanent bridges cross this canal; 1 of iron, 5 wood and iron, 2 iron and stone, 6 masonry, and 11 masonry and iron. Navigable passage, from 30 to 60 metres.

POMMERÉUL AND ANTOING CANAL.

The purpose of this canal was the establishing of a junction between the Haine and Escaut Canals, on Belgian territory, and to protect Belgian commerce from the heavy dues imposed on boats frequenting the Mons Canal and going to different sections of the country via the French part of the Escaut Canal, and also from the French customs formalities. The canal is 25,168 metres long. The locks are flooded by means of steam pumps which have a capacity of raising 30,000 cubic metres of water in 24 hours.

Towing.—Towing is performed by men and horses. Vessels towed by horses have the right to advance before all others.

Navigation tax.—One centime per cargo ton and per kilometre. Empty boats furnished with a pass, costing 20 centimes, delivered by the collection office belonging to the Government, free.

Boats.—Maximum tonnage, 312 tons.

Description.—Total length of canal, 25,168 metres. Number of locks, 13. Average length, 39 metres. Average width, 5 metres 20 centimetres. Depth varies from 1 metre 75 centimetres to 2 metres 27 centimetres. Construction of locks, principally of rough stone. Average time necessary to flood locks, three and one-half minutes. Average passage through locks, twenty-nine minutes. Number of bridges, 18, of which 9 are draw and 9 permanent, 14 of iron, 1 of wood, and 3 of masonry construction. Navigable width of same, from 3 metres 88 centimetres to 7 metres 90 centimetres. Average width of towpath, 4½ metres.

OTHER CANALS.

The Ourthe, Sambre Lys, Dyle and Demer Canals are old and important water ways of Belgium. The first important use of the Sambre Canal was by Louis XIV, in transporting supplies for the French army during the siege of Namur.

Towing.—Towing generally performed by horses.

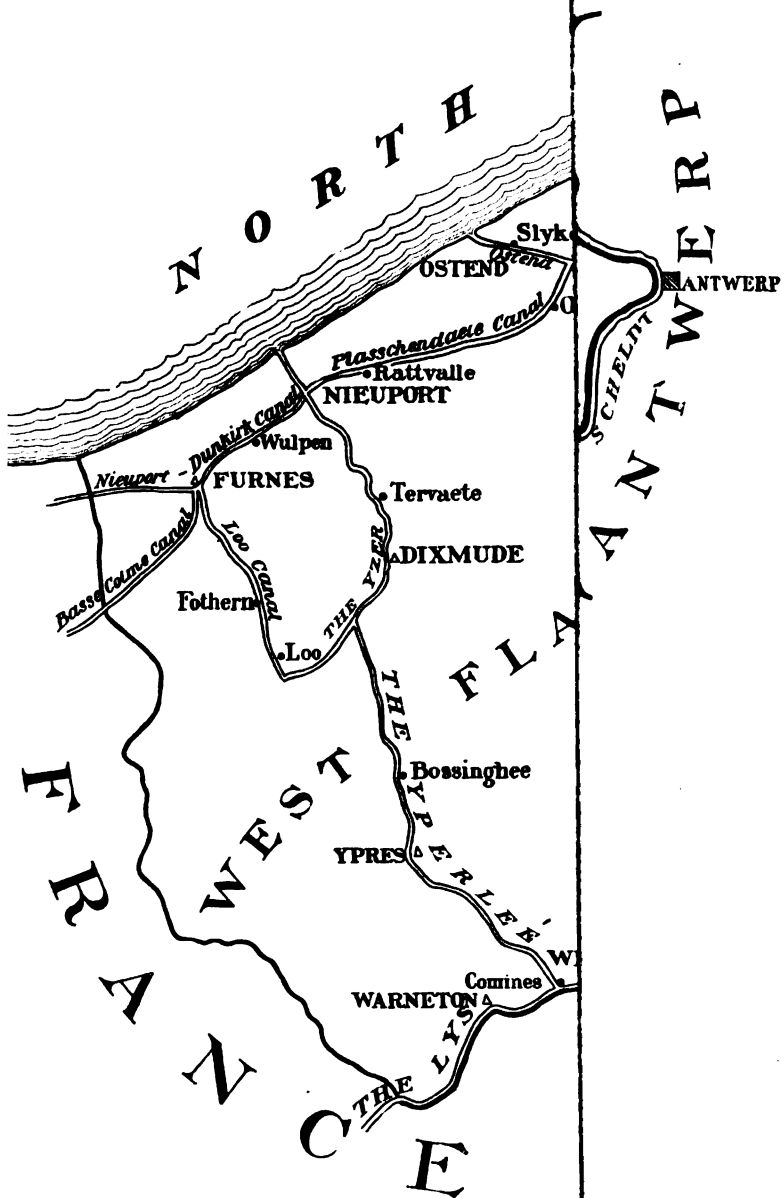
Boats.—Tonnage varies from 15 to 36 tons on the Ourthe Canal, and from 50 to 270 on the Sambre.

Nature of transports.—Coal, cut stone, paving, rough stone, and wood.

GEO. W. ROOSEVELT,

Consul.

UNITED STATES CONSULATE,
Brussels, November 26, 1889.



GHENT.

REPORT BY CONSUL BUTTERFIELD.

ANTIQUITY OF BELGIAN CANALS—TIME AND MANNER OF CONSTRUCTION.

The venerable antiquity of nearly all the most important canals in this part of Belgium is such, that the time and manner of their construction, if properly investigated, might well lead to disquisitions of a scope and character quite beyond the average contemplation. It has, therefore, been my endeavor to keep clear of encumbering details, and to present as concise a view as a historical subject carefully digested will permit of. The extent, capacity, traffic, and management being elsewhere given will not now call for especial prominence.

The Terneuzen Canal.—An enumeration of the canals of this consular district most appropriately begins with the Terneuzen Canal as one of first importance, not alone to this city, which it connects with the sea, but to the whole of Flanders, which, thanks to it, is largely enabled to avoid the attempted commercial monopoly of Antwerp. Perhaps a sufficient account of this canal has already been given in my report on the "Navigation of the Scheldt," prepared for the Navy Department and forwarded to you on the 12th of September, 1888. However, I may repeat that efforts to open up direct communication from Ghent to the sea date back to the year 1251. Intermittent, partially successful, work, often interrupted or undone by shifting sands, was kept up for centuries; but not till 1823 was the canal ever satisfactory. In that year the plans of Messrs. Noel and Van Diefelen were brought to a successful completion, and, under the auspices of the Dutch Government the Terneuzen ship canal was formally opened to navigation. Of course at this time the canal lay under one jurisdiction; but since the Belgian revolution the Dutch frontier intersects the canal at Selzarte, leaving the Terneuzen outlet to Holland.

This double jurisdiction, whereby Ghent is injured and Belgium made a dependent, is a source of annoyance, if not, indeed, of irritation. This very year it has been announced, as you will remember, that the canal is to be closed to navigation for repairs at the Dutch end. The management of this canal belongs to the state, which has a special corps of engineers, police, and others employed to enforce its regulations. These are set forth in the "reglement général," a copy of which is herewith transmitted. There is a singular and special regulation to the effect that a white mast headlight should, under the ordinary circumstances of a dark night, be plainly visible at 900 metres, while red and green lights are required to shine out at 500 metres.

The navigation dues of this and the other canals have been collected and tabulated on a separate sheet. The figures relating to canal traffic have been similarly treated.

Moervaert Canal.—This canal serves as a leak between the Terneuzen Canal and the country to the east of this place, usually known as the "Pays de waes." Its origin seems doubtful, although it was deepened and thoroughly repaired in 1778; communicates with the waters of the Zuidleede, Laufleede, and Stekene. This last is a so-called "communal" canal, being under the direct management of the local authorities. Its importance is small, but its age respectable, for it is said to have been built in 1351; enlarged in 1853.

Dues of .01 franc per ton of 1,000 kilogrammes measurement are charged at a bridge called "Koeibrug," besides which and the ordinary navigation dues there are dock dues at Stekene.

Gand par Bruges & Ostende Canal.—The Ghent-Ostend Canal, one of the four great waterways that center at Ghent, is a canal of comparatively recent growth. Commenced in 1613, the work, twice interrupted, was resumed in 1664, and in 1724 the Bruges section was finally, if roughly, cut through. However, the dimensions proving insufficient, improvements were added in 1751. Seven years later, proper regulations having been prescribed and enforced, navigation on this section became of recognized importance. The canal was further widened and deepened in 1856; while in 1862 it was brought into the Ghent docks by means of the Canal de Raccordement. As to the section from Bruges to Ostend, the part from Bruges to Plasschendaele is the oldest (1622). In 1666 the canal was prolonged to Slykens, enlarged in 1751, and finally carried forward early in the present century from Slykens to the Bassius du Commerce at Ostend (1817–1820).

Schipdonck Canal.—The Canal de Dérivation de la Lys takes its name from the hamlet of Schipdonck, where it crosses the Ghent-Ostend Canal; thence to Gecloo and Heyst. Its chief purpose is to drain off the superfluous waters of the Lys, and thus to prevent the inundations to which this city was once frequently liable.

Plasschendaele à Nieuport Canal.—Differing from the Schipdonck, which is of comparatively recent construction, the Plasschendaele Canal dates its origin to the early part of the sixteenth century. It receives the Moerdyck and Bourgoyne, which in turn supplies the Tzer and the canals of the Furnes-Ambacht system. Falls into the Ghent-Ostend Canal close to the latter place.

Lys River Canal.—The attempt to use the Lys for canal purposes was first made in the time of Louis the XIV, by whose orders a lock was built at Comines (now in Belgium, then in France). In 1723–1724 another lock was made, and the course of the river somewhat straightened (1780). Forty years later King William of Holland especially charged the states of Flanders (Etats des Deux Flandres) with the care and supervision of this important water way. Movable bridges on the turning principle were introduced in 1824. Finally two more locks were provided at Vive St. Gloi and at Astrue, and the old ones rebuilt at Harlebeke and Comines (1866–1869).

The process known as "rouissage," or the retting of flax, is permitted on this river from 15th of April to the 15th of October in each year. Instead of the flax lands being flooded, as I am told is the case in some parts, the flax is collected into bags (balloons) which are then made to soak. The waters of the Lys are said to possess remarkable virtue in this respect, for the flax thus soaked meets with particular favor.

Factories and washhouses have the right to use the Lys, provided their use of the water does not interfere in any way with navigation. However, the "ponts et chaussées" (roads and bridges) decides finally in the matter.

Roulers à la Lys Canal.—As is sufficiently implied by its name, this canal serves to place Roulers, so to speak, "on" the Lys. It is of recent construction, and was, I believe, until lately managed by a company, who, since the expiring of their charter, have surrendered the canal to the State.

Bossuyt à Courtrai Canal.—For some distance before reaching Ghent the Upper Scheldt and Lys are almost parallel, and the purpose of this canal is to join the two rivers. The right to build, maintain, and man-

age the Bossuyt Canal was first sought in 1838, but was not granted until 1857. Its stock is divided into shares, all regularly quoted.

Haut-Escaut River and Canal.—The upper part of the Scheldt was originally improved some time in the tenth century. These attempts were somewhat primitive and failed to give the proper facilities for navigation. In the sixteenth and seventeenth centuries, however, thanks to extensive works systematically carried out, the river acquired an importance never since lost. Just before receiving the Lys at Ghent the Upper Scheldt takes the name of "Canal des Chandronniers." This short but interesting section is venerable with age, for it has existed, I believe, as a canal since 1194.

Below Ghent the Scheldt so deepens and widens as to rapidly become far more than a mere canal-river, and hence falls outside my present subject. Like the Terneuzen Canal, it is treated in my report on the "navigation of the Scheldt."

Dendre Canal.—This practically artificial stream passes through or close to the towns of Otts, Grammont, Ninove, Alost, and flows into the Scheldt at Termonde. The navigation of the Dendre became practicable in the seventeenth century. It has quite recently been much improved (1863–1878).

Yzer River and Canal.—A small though historical river, the Yzer became a canal in the sixteenth century. About 1830 it was deepened, and subsequently, by a law passed in 1858, was thoroughly renovated, dikes and locks being also added.

Ypres à l'Yzer Canal.—The origin of this canal was a grant to the city of Ypres by the Countess Marguerite, in 1251, of a concession from Bossinghe to the Yzer. Later, in 1638, Philip IV of Spain ordered certain changes to be made, whereby part of the original canal (Yperlée) was abandoned.

The management pertains to the provincial authorities of western Flanders by decree of the King of the Netherlands, dated December 17, 1819.

Canal di Loo.—This canal, managed also by the province, was constructed in the fifteenth century, but does not seem to have been touched for improvement until some 20 years ago, when its bridges, locks, and dikes were built anew.

Nieuport par Furnes Canal.—By decree, dated August 13, 1638, the right to construct a canal from Dunkirk to Nieuport and Plasseheuaele was granted by Philip of Spain to the cities of Dunkirk, Furnes, and Bruges. From the peace of Utrecht to 1826 the canal, owing to the diminished importance of Dunkirk, was little used. The transportation of coal, however, having greatly developed, it was thought worth while to deepen and widen its dimensions (1829–1830). As the result of a conference in 1861 between the French and Belgian engineers, it was agreed to enlarge the canal throughout its course, each Government to bear the expense of the alterations within its territory. The stipulated provisions have, I understand, been faithfully executed.

Canal dit de Baccordement à Gand.—Sufficient mention of this canal will be found on page 6 of the present report.

EXTENT AND CAPACITY.

Next after the time and manner of construction, dealt with in the preceding notes, comes the extent and capacity of the canals. This is very fully given in the following specially prepared table. After the name of the canal you will notice that I have introduced a separate

column for the name of such of its parts as present any change in the dimensions of locks and bridges, or in the average depth of water.

Extent and capacity of important canals, with dimensions in detail.

[Standard of measurement, metre.]

No.	Name of canal.	Specific reference to its ports.	Total length of canal.	Length of locks.	Width of locks and bridges.	Height of bridges, etc.	Depth of water.	
							Summer.	Winter.
1	Terneuzen.....	Belgium.....	17,845	*None	17.50	Drawbridges	†6.30	†6.30
2	Menvaert.....	.....	21,113	.....	6.00	do	1.40	1.70
3	do.....	Roodenhulze.....	.....	50.00	do	do	.....	.....
4	Stekene.....	.....	5,012	None	4.85	do	1.10	1.55
5	Gand par Bruges à Ostende.....	.....	70,132	.....	.....	do	2.00	2.30
6	do.....	Ghent.....	.....	.....	6.90	do	.....	.....
7	do.....	Bruges.....	.....	70.00	8.20	do	3.00	3.00
8	do.....	Damme.....	.....	82.00	12.00	do	†4.30	4.10
9	do.....	Slykens.....	.....	.....	10.90	do	3.70	3.50
10	do.....	Contredam.....	.....	64.00	12.00	do	.....	.....
11	Schipdonek or Dérivation de la Lys.	.....	27,408	42.00	5.25	‡3.75	2.00	2.30
12	Plasschendaële à Nieupoort.....	.....	21,018	90.00	6.40	Drawbridges	†2.20	2.00
13	do.....	Comte.....	.....	45.00	5.50	do	.....	.....
14	Lys (river).....	Coutrai.....	112,532	41.45	5.40	4.35	1.80	1.80
15	do.....	Deynze.....	.....	42.20	5.40	4.35	1.90	2.10
16	Roulers à la Lys.....	.....	16,585	40.90	5.40	3.78	1.80	1.80
17	do.....	Rumbeke.....	.....	.....	.....	4.50	.....	.....
18	Bossuyt à Courtra ||	.....	37,748	38.00	5.15	3.50	1.80	1.80
19	Haut-Escaut.....	.....	102,955	.....	.....	.....	.....	.....
20	do.....	Hainaut.....	.....	40.30	5.30	4.60	1.90	2.10
21	do.....	Flanders.....	.....	41.74	6.50	4.50	1.90	2.10
22	do.....	Chandronniers.....	.....	.....	5.70	4.25	1.90	2.10
23	do.....	Strop.....	.....	41.50	6.50	2.87	1.90	2.10
24	do.....	Gentbrugge.....	.....	80.00	12.50	Drawbridges	1.90	3.50
25	Dendre Canalisée.....	.....	65,381	41.77	5.20	3.70	1.90	1.90
26	do.....	Termonde.....	.....	27.25	5.20	3.70	1.90	1.90
27	Yser (also river).....	.....	41,450	.....	9.34	2.90	1.00	1.00
28	do.....	Stavele.....	.....	.....	6.00	Drawbridges	1.50	1.50
29	do.....	Fentelle.....	.....	.....	.....	do	1.70	1.70
30	do.....	Van Exem.....	.....	.....	.....	do	1.30	1.30
31	do.....	Ypres à Yzer Canal.....	.....	.....	5.40	do	1.50	1.50
32	do.....	Dixmude.....	.....	.....	5.60	do	1.70	1.70
33	do.....	Nieupoort.....	.....	45.10	5.55	do	1.80	1.80
34	Ypres à l'Yzer.....	.....	15,336	37.00	6.25	do	1.40	1.40
35	Canal de Loo.....	.....	14,332	27.35	5.30	do	1.70	1.70
36	Nieupoort par Furnes.....	Ecluse de Nieupoort.....	18,796	43.00	5.40	do	1.30	1.30
37	do.....	Ecluse de Furnes.....	.....	45.10	7.00	do	1.90	1.90
38	Gand Raccordement.....	.....	2,099	.....	12.00	do	8.00	3.30
39	do.....	Ecluse de Tolhuis.....	.....	85.00	.....	.....	.....	.....

* There are no locks between Ghent and Selzaete.

† In coming to Ghent vessels drawing more than 5.30 millimetres must remain at the outer docks or "avant port."

‡ It is presumed that the greater depth of water in summer than in winter is partly due to the flooding and subsequent drainage of the flax-pits, in the process of decomposition, called "retting" (French, rouissage). See also report.

§ From the Lys to the points of intersection with the Ghent-Ostend Canal, there are drawbridges; elsewhere stationary ones.

|| The locks can remain closed for one hour to boats going up stream.

CANAL TRAFFIC.

The last official statistics on this subject appear to have been published in 1880, and to cover no more than the period from July 1 to December 31, 1879. The cost of collecting information on such a complete topic must have been very great; hence it is, I apprehend, that no efforts are made to keep the statistics up to date. To present a simple but clear view of the subject, out of the mass of figures, I have se-

lected such as relate to certain sections of each canal. Where canals constantly intersect each other, and where merchandise is frequently unloaded at intermediate points of small importance, it is necessary to keep the termini well in mind. So much being premised it is easier to understand the true imports of the following table on "caual traffic."

Traffic for six months ending December 31, 1879.

[Standard of measurement, ton of 1,000 kilogrammes.]

Name of canal.	Reference to separate sections.		Down-stream.	Up-stream.
	From—	To—		
Terneuzen	Muide	Seizaele	118,815	32,365
Moervaert	Terdonck	Wachtebeke	19,020	16,765
Stekene	Stekene	Moervaert (Junction)	2,585	2,055
Gand & Ostend	Ghent (Lys, Dérivation)	Bruges	109,190	15,025
Do	Bruges	Ostend	*3,330	*28,420
Schipdonck or Dérivation de la Lys	Deynze	Ghent-Ostend (Junction)	23,730	52,600
Plaschendaale & Nieuport	Nieuport	Rattervalle	23,440	13,695
Do	Oudenbourg	Plaschendaale	81,855	6,855
Lys	Ousselgem	Deynze	25,855	43,935
Do	Courtral	Harlebeke	42,015	33,140
Do	W. velgem	Courtral	29,990	83,825
Roulers & la Lys	Roulers	Rambeke	3,290	10,890
Bossuyt & Courtral	Courtral	Harlebeke	36,615	9,100
Haut Escaut	Audenarde	Ghent (Chaudronniers)	238,255	8,600
Do	Pont-à-chin	Warcoing	317,250	4,020
Dendre canalisée	Grammont	Ninove	72,810	80,850
Do	Ninove	Alost	71,515	82,995
Yzer	Dixmude	Tervaele	3,970	21,765
Ypres & l'Yzer	Ypres	Bossinghe	3,850	465
Canal de Loo	Loo	Fothern	2,145	590
Nieuport par Furnes	Furnes	Wulpen	15,995	16,135
Gand Raccordement	Palingshuizen	Muide	68,650	158,085

* These figures represent the amount of traffic which, leaving Bruges, reaches Ostend, and *vice versa* the traffic leaving Ostend which reaches Bruges. Much that is originally shipped at either of these places finds its way into branch canals or is unloaded before coming to the terminus, and is therefore not taken into account by the figures in the table.

It may further be of interest to note the size (maximum and average) of the boats navigating the various canals. The following is taken from official sources:

[Standard of measurement, ton of 1,000 kilogrammes.]

Name of canal.	Maximum.	Average.	Name of canal.	Maximum.	Average.
Moervaert	125	.....	Haut Escaut	335	815
Stekene	40	.....	Dendre	335	.....
Gand & Ostende	335	.....	Yzer	250	50
Schipdonck	335	.....	Ypres & l'Yzer	270	50
Plaschendaale	320	.....	Canal de Loo	40	.....
Lys	300	175	Nieuport par Furnes	200	75
Roulers & la Lys	300	175	Gand Raccordement	650	.....
Bossuyt & Courtral	300	175			

The Terneuzen Canal, since it is also a ship canal, is not given in the above classification. The merchandise transported by canalboat in the two provinces of eastern and western Flanders consists mostly of coal, coke, mineral ore, iron, and other metals; sand, chalk, cement, rough stone, slate, and marble; potteries and glassware; lumber, firewood, and charcoal; cereals and flour; beet roots; ashes and manures, and

finally products of general industry. These latter are not specifically mentioned, but are intended, I suppose, to cover all cases not previously enumerated.

MANAGEMENT.

In almost every instance this belongs either to the state, the province, or the commune. Although navigation dues are charged as per inclosed table, they appear far from exorbitant, and are probably calculated to produce just enough for repairs. Where canals are so intimately interwoven with the country's very history, it may be supposed that everything that long experience can suggest has been done to make them as little of a charge and as much of a public benefit as possible. The fact remains, however, that their long existence and intricate development make it an almost impossible task to trace the multitudinous aspects of their slow evolution. Time and opportunity both fail me for a historical analysis of their management, hence I must somewhat regretfully, it is true, refer you to the "Règlement Général des Voies Navigables administrées par l'État" and the subsequent "Règlements Particuliers," both published in the "Moniteur Belge" under date of May 29, 1889.

I now give the table on "navigation dues."

Canal navigation dues.

[Standard of measurement, ton of 1,000 kilogrammes.]

Name of canal.	Amount per kilometre.	Name of canal.	Amount per kilometre.
	<i>Francs.</i>		<i>Francs.</i>
Terneuzen .....	.005	Haut Ecaut	1.0016
Moervaert .....	.0025	Dendre canalisée .....	.004
Stekene .....	.01	Yzer .....	.005
Gand & Ostende .....	.0002	Ypres à l'Yzer .....	.006
Schipdonck, or Dérivation de la Lys .....	.0016	Canal de Loo .....	.005
Plasschendaale & Nieuport .....	.005	Nieuport par Furnes .....	.005
Lys .....	.0025	Gand Raccordement .....	.002
Bossuyt & Courtrai .....	.03		

* For boats going from the Lys to the Scheldt there is an additional charge of .03 francs per ton of cargo.

† There is a further due of .006 francs per ton of cargo per kilometre.

EFFECTS ON PRICES.

It stands to reason that to usefully examine the effect of a system of canals in cheapening prices would require if not perfectly, at least moderately accurate, knowledge of the circumstances of trade and commerce prior to the construction of the most important canals. In this part of Belgium, with canals centuries old, it becomes the labor of a lifetime to make an investigation that might intelligently show the effect on prices of a system of canals.

Whatever, in ancient times, may have been the effect of canals, it is interesting to note by an inspection of the table below, headed "Navigation of the Ghent Canals," that their usefulness seems to be impaired. You will notice that the tonnage for 1880 of the boats counted at the Pécherie lock is about half that for the year 1876; while at the Pont Madou the number of boats is about 1,000, and at the Muide nearly 1,500 less for the same period.

Navigation of the Ghent canals, excluding vessels other than those used for ordinary canal transportation.

Boats passing lock at—	1876.		1877.		1878.		1879.		1880.	
	No.	Ton-nage.	No.	Ton-nage.	No.	Ton-nage.	No.	Ton-nage.	No.	Ton-nage.
Pécherie	4, 873	462, 388	4, 704	457, 068	4, 261	319, 610	4, 257	344, 158	4, 728	280, 410
Pont Madou	4, 716	574, 933	4, 766	596, 984	4, 125	479, 319	3, 646	479, 225	3, 658	514, 868
Muide	4, 546	332, 035	4, 562	389, 898	4, 172	294, 550	3, 254	314, 776	3, 089	302, 242

Freight rates per ton (as *e. g.*, in the case of coal) may serve to give one an idea of canals in their relation to competing railways, and consequently, at least *pro tanto*, of their effect on prices. They are as follows, and will bring this report to an appropriate close:

Rates per ton for coal October 31, 1889.

From St. Ghislain, near Mons, to—	By canal.	By rail.
	<i>Francs.</i>	<i>Francs.</i>
Courtrai	2.60	3.84
Ypres	4.80	4.30
Bruges	3.20	3.69
Antwerp	2.70	3.66
Ghent	2.70	3.08
Brussels	3.10	2.76

In canal transportation it often occurs that there is a question of convenience involved, as where works or factories stand close to a canal, in which case cartage is often saved. In Ghent alone there are over 250 bridges crossing canals, thus showing that they are numerous all over the city. Hence their frequent greater convenience than railroads.

F. W. L. BUTTERFIELD,
Consul.

UNITED STATES CONSULATE,
Ghent, November 9, 1889.

DENMARK.

REPORT BY CONSUL RYDER, OF COPENHAGEN.

In reply to the circular dispatch from the Department, under date of the 31st July last past, calling for a report upon the canals constructed in this kingdom for the benefit of general traffic, as well as for irrigation purposes, I have herewith the honor to report that under the first category there are but two, namely, the Odense Canal and the Frederie the Seventh's Canal.

First, the Odense Canal, connecting the inland town of the same name, in the Island of Fynen, with the entrance to the Odense Frith, is one of great benefit to the shippers of the agricultural products of the island, as also to the importers of foreign goods, such as coal, iron, etc., the expenses of land carriage, as well as the expenses of transshipment at the Frith, being thus avoided, the cargoes being loaded in small-sized vessels at the Odense quay and taken without hindrance to sea to prosecute the voyage to their different ports of destination.

H. Ex. 45—7

This canal is 26,600 feet in length, and the construction was first commenced in 1796, and completed in 1803; was further deepened in 1877-1882, and again deepened and widened in 1883-1886. It has now a depth of 15 feet with a width varying from 35 to 60 feet; and in the general trade of 1888 there passed through this canal a total number of 752 vessels of the aggregate tonnage of 82,970 tons, consisting of 245 steam vessels of 44,400 tons and of 507 sailing vessels of 38,570 tons.

Second, Frederic the Seventh's canal between the deeper parts of the Limefjord in Jutland, respectively east and west of Logstør. The canal is constructed alongside of the Limefjord southern coast line from Logstør town toward the southwest, so that vessels navigating the western part of the Limefjord may avoid the shoals in the frith west of Logstør. The canal has a length of 15,500 feet between the mouths of the harbors at the two extremities, and was opened to navigation on the 13th July, 1861, and has a depth of 9 feet with a width on the water line varying from 75 to 90 feet. The canal is used by small vessels engaged in the general traffic between the small towns situated on the western parts of the Limefjord; and the annual number of vessels and boats passing through is about 900, with an aggregate tonnage from 50,000 to 70,000 tons. Vessels making use of these canals are subjected to the following canal dues, viz:

On the Odense Canal: All steam and sailing vessels and all boats above 4 tons, laden or in ballast, in addition to the customary Government harbor dues, or cargoes landed or shipped, the dues are levied as follows:

1. All vessels registered in the Odense custom-house or in places of the same customs district, both on inward or outward passage, have to pay canal dues per ton of 1½ cents.

2. All home vessels registered in other customs districts; as well as all vessels sailing under the flags of privileged nations with a rate of canal dues per ton of 2½ cents.

On the Frederic the Seventh's Canal as follows:

1. On all vessels under the national flag or under the flags of privileged nations, as also boats from 4 to 32 tons burden, with canal dues per ton at 10½ cents.

2. On all home and foreign vessels under privileged flags above 32 tons, with a rate per ton of 16 cents.

3. All boats of or below 4 tons pay altogether the sum of 50 öres, say, 13½ cents.

4. Fishing boats with wells only pay half rates of canal dues.

5. All vessels employed exclusively for lighterage or towing purposes are exempted from payment of dues.

6. All vessels of more than 4 tons that may be passing several times in the course of 1 week, after payment of the dues on the first passage, are exempted from further payments for the rest of the week.

7. Foreign vessels under unprivileged flags are charged with an additional rate of one-half above the amount levied on vessels under privileged flags.

Next with respect to canals for irrigation purposes: It may be as well in the first place to give a short account of that part of the kingdom where these works have been constructed. In the early ages the interior of Jutland was covered in great part with large forests of pine wood; but owing to the wholesale and wasteful cutting down of the wood by the inhabitants these forests, toward the sixteenth century, had almost entirely disappeared, leaving by degrees in their place a large and dreary waste of heath lands, without any attempts having been made

towards bringing the same under cultivation; and it was only at the close of the unfortunate war of 1864, when Denmark was stripped of her valuable Duchies of Schleswig-Holstein, that this great national loss led to strenuous efforts being made towards the carrying out of improvements in many ways in the remaining parts of the kingdom.

Thus in 1866 a society was founded under the title of "The Danish Society of Heath Lands" for the purpose of clearing and fertilizing this vast tract of land in Jutland, covering a superficial area of about 140 Danish square miles (1 Danish mile = $4\frac{1}{2}$ English miles), this area being traversed by several water courses of greater or lesser extent, running from east to west and diverging to the North Sea.

The society now consists of near 4,000 members, amongst whom are to be found several public institutions and many wealthy private individuals, who have contributed their shares on purely patriotic grounds; and it has been by the aid of these contributions, together with considerable subventions from the state, that in the last twenty-three years a new life has been given to this part of the Kingdom, as also by the construction of roads and railways.

Of the 140 Danish square miles of heath lands existing in 1860, there now remains but about 90 square miles, 40 having been converted into meadows and fields and the other 10 square miles into plantations.

The following classes of works are undertaken by the society, namely:

(1) Construction of irrigation canals; (2) plantations in general; (3) limited plantations on the different properties, and inclosures with quick-set hedges; (4) draining of bog lands; (5) cultivation of marsh lands.

The society has now superintended the construction of 145 irrigation canals, which have a total delivery of 2,200 cubic feet of water per second, the greater part of the canals having a length varying from 5 to 15 English miles.

A complete irrigation will require for the entire period of irrigating a delivery of one-fifth of a cubic foot per second for 1 barrel ($1\frac{1}{2}$ acres) of land measure; but the meadows receive four to six times that volume of water, when they receive an alternating watering. A large quantity of the water from the canals is, however, only used for moistening the land, and which will only call for one-fourth of the above-mentioned quantity.

The total superficial area of the irrigable land which has been converted in this way amounts to 15,000 barrels of land (21,000 acres), and which by these proceedings have now an increased value of 6,000,000 kroners (\$1,600,000). The yield of these meadows is of about 4,000 pounds of hay per barrel ($1\frac{1}{2}$ acres) of land. Only one crop is made, and in lieu of an aftermath the cattle are put out on the fields during the autumn. The society prepares all the plans of construction of these canals, as well as the irrigation, and superintends the execution of the works free from any charge to the proprietors; but these latter have to defray all costs of the works. The total cost of the canals has been from 300 to 1,000 kroners (\$80 to \$270) per cubic foot of water. Each canal has its own local administration board elected by the parties interested in the irrigation in question, and a certain volume of water is placed at the disposal of each party concerned for the whole period of irrigation, namely, from the 1st April to 1st December, and they must then receive it, so that there may be no disturbance in the arranged order for the use of the water amongst all parties concerned. The water is distributed to the associations by the means of wooden troughs, the working of which is placed under very strict control. These canals have been con-

structed at as moderate a cost as possible; the ground in which they are dug being generally of sandy, but at times marshy, nature; and their fall has been regulated so as to give a rapidity of water flow of $1\frac{1}{2}$ feet per second.

The interior slopes of the canals are at the proportional rate of $1\frac{1}{2}$ of base to 1 of height, and the exterior slopes of the banks have 3 to 4 of base to 1 of height, the banks at the summit being of sufficient width to serve as a carriageway, this width being from 10 to 12 feet all along the great canals. The aqueducts under the canals are generally of masonry or of glazed earthenware pipes. The society during their twenty-three years' labor have now intercepted the greater part of the water courses of the heath lands by canals, wherever this could be executed without too great pecuniary cost, and are now engaged on the improvement of some old works of bad construction. It is also their intention to carry on experiments for a better system of irrigating. During these twenty-three years they have also completed four hundred and fifty plantations of a total extent of 36,700 barrels of land (51,400 acres), and are the owners of eight properties in different parts of the heath lands of a total superficial area of 4,500 barrels of land (6,300 acres) for the carrying on of experiments in planting, and by which they have succeeded in being able to solve with some certitude a question of so great importance to the interior of Jutland.

HENRY B. RYDER,
Consul.

UNITED STATES CONSULATE,
Copenhagen, November 16, 1889.

FRANCE.

HISTORY OF FRENCH CANALS.

REPORT BY CONSUL-GENERAL RATHBONE, OF PARIS.

A glance at the map of France, if it gives the canals and navigable water courses, is sufficient to convince the most casual observer that the country is very rich in both of them. In that respect France occupies the first rank among European countries; her navigable rivers are 11,855 kilometres long; her canals 4,789 kilometres. These figures are given for the year 1888. The greatest number of canals are to be found in the departments bordering more or less on Belgium; the largest number of navigable rivers that carry craft of a considerable tonnage are likewise found in the north of France. It would be difficult to estimate the exact cost of so extensive a network, inasmuch as it is the work of several centuries, and has been paid for in a variety of ways by means of a large number of resources differing widely in their origin; moreover, it requires changes in improvements, etc. In some cases the changes are of so extensive a character that the original works have almost entirely disappeared. With regard to the time of construction, no definite time dates can be given without drawing up an exceedingly elaborate and complicated table.

The works were seldom carried out at once and entirely. The different periods during which changes and improvements were made may be considered as periods of construction. As already stated, the changes

have often been of a sweeping description. In several cases troops were employed in cutting canals or in assisting the insufficient number of workmen engaged for the purpose. Thus during the reign of Henry IV 6,000 soldiers were employed on the works in connection with the Canal de Briare.

In 1719 the Canal de Loing was conceded to the regent, Duke of Orléans, and his heirs forever. The duke caused the work to be executed by large bodies of troops.

Previous to the revolution of 1789 the canals were generally cut by parties to whom a concession had been granted, the conditions of which varied according to the amount of influence enjoyed by those who received the privilege.

A great deal of jobbery was the natural consequence of this arrangement. But after 1791 the French Government took the management of all canals into its own hands. All canals the construction of which had already been commenced by grantees were finished under the direction of the Government. But the treasury was not able to bear the strain thus brought upon it. In order to find the money required Napoleon decided to sell a certain number of canals belonging to the state; among others, those of the Midi, d'Orléans, and Loing, of which particulars are given hereafter.

During the reign of Napoleon I (1804–1815) 200 kilometres were opened to navigation. The principal canals dug during the same period were those of the Haute-Seine, Blavet, Marous à Rochelle, Arles à Bouc, and Ile et Rance, to which reference is made further on. All the works were carried out and paid for by the state. After the year 1818 all works connected with canals were executed by the treasury by means of loans and by the system of concessions which appeared to return to favor.

From 1830 to 1848 work was pushed forward with great activity; 2,000 kilometres were opened to navigation at a cost of over 7,000,000 francs. A number of useful laws regulating inland navigation were also passed. A few concessions were granted before 1837, and in this way the canals named (de Roanne à Digoin, de la Sauldre à l'Oise) in Table A and several others of minor importance were cut.

During the four stormy years that followed the Revolution of 1848 the national exchequer was more or less dilapidated and a great financial crisis ensued. Accordingly little was done to increase the canal mileage. Seventeen million francs were devoted to finishing canals in course of construction. Those called de la Marne au Rhin and de l'Aisne à la Marne were among the number.

When Napoleon III became Emperor he effected a sweeping change in the law relating to the cutting of canals. The commencement of all works connected with them was henceforth regulated by Imperial decree. He retained this privilege until his fall in 1870.

The attention given to railroads meanwhile had made the authorities underestimate the value of canals. While the laying down of railroads was pushed with the greatest activity, canals became more or less neglected, but in 1860 a reaction took place in favor of them. The treaty of commerce signed by the Emperor and Mr. Cobden pointed to the necessity of perfecting as far as possible the instruments of production in France, so as to enable the country to hold its own in the matter of industrial competition. The Government accordingly devoted large sums to improving the existing canals, and to constructing fresh ones. The funds remaining from the loan of 500,000,000 francs, raised to defray the cost of the Italian war in 1859, were also devoted to the same

purpose. But, with the single exception of the one named de la Haute-Marne (see Table A), no canals of great importance were cut during this period. The credits voted were chiefly intended to defray the costs of improving existing ones in various ways.

Napoleon III did not favor the system of concessions. He granted a few of hardly any importance, while he bought up several important ones granted long before his accession.

The period included between the reëstablishment of the Republic in 1870 and the year 1887 is divided into two distinct parts, viz:

During the first part of 1870-78, canal work suffered severely in consequence of the disasters of 1870, and the works planned by the Emperor absorbed nearly all the funds available. France in these 7 years spent about 28,000,000 francs on canals alone.

In 1879 the minister of public works drew up an extensive project, for the carrying out of which large sums had been voted; 3,600 kilometres were to be altered and improved, and fresh canals with an accumulated length of 2,400 kilometres were to be constructed. The estimated costs of these works were about 150,000,000 francs. In that year an extraordinary credit of 12,000,000 francs was set apart for the purpose, besides the sum set down in the general budget. The credits destined for the works in hand gradually increased, year by year, until 1883, when they attained the high figure of nearly 40,000,000 francs; a steady decline, however, followed.

The progress of the works was not sufficiently rapid to exhaust the sums so lavishly voted, and it was thus that the money granted diminished in the following proportion year after year:

	France.
1883	39,573,693
1884	22,772,437
1885	18,568,830
1886	15,254,137
1887	10,677,685

The question of toll money in connection with canals has gone through many complicated phases. After the revolution of 1789 the right of toll was practically abolished, and replaced after a time by rates called "droits de navigation." During the reign of Napoleon III these were gradually lessened until they reached the low sum of, for goods rated first class, \$0.001; second class, \$0.0004 per ton per kilometre.

The laws of December 2, 1879, and February 19, 1880, abolished these rates altogether.

Table A gives the chief facts and figures relating to the French canals above 20 kilometres long.

The figures giving the number of steamboats and steam tugs are not included, but they are not very numerous. The figures placed under the heading "Not steam" do not include some rafts and a few auxiliary craft that do not answer to the description of boats properly so called.

The figures stating the length of the different canals do not include some of the small lateral branches some of them possess. In the case of canals not wholly French, the figures show the mileage within the limits of France. The same remark is applicable to the boats, bridges, and flood gates connected with them.

The following table will give a fair idea of the expenses incurred in constructing and keeping in repair some of the foregoing canals until December 31, 1889. In several cases it has not been possible to obtain

complete figures, but in that case those given below are as near the exact amount as possibly could be obtained :

Complete expenses till 1889.

	Francs.
Aisne à la Marne.....	24,237,969
Ardennes.....	19,078,076
Aire.....	4,077,749
Berry.....	27,803,290
Blavet.....	2,978,390
Bombourg.....	3,218,047
Bourgogne.....	58,556,197
Briare.....	6,390,055
Calais.....	2,041,379
Centre.....	17,164,669
De la Charente à la Sendre.....	1,917,488
À la Garonne.....	62,099,620
À la Loire.....	33,999,158
De Marans à Rochelle.....	13,507,097
Haute-Marne.....	17,037,743
De la Marne au Rhin.....	86,088,242
De Naates à Brest.....	49,118,893
Nivernais.....	28,861,154
L'Ourcy.....	179,089
St. Quentin.....	3,794,995
Du Rhône au Rhin.....	24,205,724
Renbaix.....	8,816,494
Sauldre.....	1,721,989
Haute-Seine.....	10,207,062
Sensée.....	1,993,642
Somme.....	12,499,217

An important feature connected with navigation has long been neglected in France, *i. e.*, numbering and classifying the boats and craft of every kind on canals and navigable rivers. The first census of these was taken on October 15, 1887. It is impossible to give an exact idea of them, without going into particulars, which would far outreach the importance of the subject with regard to the manner in which the other facts pertaining to French canals have been given. The boats are of almost every conceivable size, shape, and tonnage, according to the canal on which they are found and the regions in which they were built. They are divided into eleven groups. Each group embraces all the boats more or less resembling each other by their style of construction. Some have decks, others are without; a few are built of iron while the greater number are wooden. They are built chiefly in France and Belgium. Their owners, captains, and crews are French with a fair sprinkling of foreigners, chiefly Belgians. Those intended principally for the conveyance of passengers have or have not cabins, according to their class and the nature of their traffic. The annexed statement gives important figures with regard to them.

Number of boats of all kinds exclusive of steamers..... 8,527

Length—

From 38.58 metres and upwards.....	434
From 33 to 38.50 metres.....	3,125
Less than 33 metres.....	4,968

Built—

With decks.....	4,212
Without decks.....	4,315
Of iron.....	8,088
Of wood.....	439

By whom built—

Frenchmen	7,499
Belgians	668
Germans	319
Other nationalities	4

Owned by—

French	7,078
Belgians	1,096
Germans	270
Other nationalities	83

Crews, including captain—

French	9,331
Belgians	1,594
Germans	718
Other nationalities	104

With cabins

7,756

Without cabins

771

Tonnage 1,632,083

Number of steamboats of every kind 161

Horse power 3,812

For conveying passengers:

Number	13
Maximum tonnage	93
Horse power	181

For carrying goods:

Number	41
Maximum tonnage	7,718
Horse power	2,306

Number of tugs 32

Horse power 1,020

Built by—

Frenchmen	83
Belgians	6
Germans	1
Other nationalities	11

Owned by—

Frenchmen	85
Belgians	16

Crews, with captains, mechanics, and stokers:

Frenchmen	3211
Belgians	55
Other nationalities	1

French measures of weight and distance mentioned in the foregoing report:

1 kilometre = 3,280.84 feet = 0.62136 mile.

1 metre = 39.37 inches.

1 ton = 2,204.6 pounds.

J. L. RATHBONE,
Consul-General.

UNITED STATES CONSULATE-GENERAL,
Paris, France, September 20, 1889.

A.—French canal statistics.

[Inclosure in Consul Rathbone's report.]

Names of canals.	Length.	Means of traction.	Depth.	Nature of towing-path.	Number of boats.		Horse-power.	Maximum average tonnage.	Bridges.	Flood-gates.
					Steam.	Not steam.				
	<i>Kilos.</i>		<i>Mètres.</i>					<i>Kilos.</i>		
Alre.....	41	Horses.....	2	Stony.....	2	271	62	300	31	1
Alsne.....	51	do.....	1.80	do.....	2	81	52	250	32	8
Alsne à la Marne.....	58	Horses, men.....	2	Stony.....	2	51	52	250	43	24
Ardennes.....	88	Horses, steam.....	1.50	do.....	1	38	60	300	60	39
Arles à Bouc.....	47.4	do.....	1.85	do.....	1	47	60	300	11	44
Berry.....	261	Donkeys.....	1.50	Sanded.....	1	527	60	60	56	4
Blavet.....	59.6	Men, horses.....	1.62	do.....	1	41	2	100	14	96
Bourbon.....	21	do.....	2	do.....	3	396	50	300	72	25
Bourgogne.....	242	do.....	2	Stony sanded.....	3	119	120	175	16	3
Briare.....	59	Men, donkeys, horses.....	1.60	do.....	1	120	180	300	5	79
Calais.....	30	Horses.....	2	Stony, sandy.....	1	518	7	300	80	41
Du Centre.....	116	Men, donkeys.....	1.50	do.....	1	12	7	70	7	1
De la Charente à la Sèvre.....	24	Oxen.....	2	Earth.....	1	12	7	70	7	5
De l'Est:										
First branch.....	272	Horses.....	2.20	Stony.....	19	438	390	200	89	99
Second branch.....	147	do.....	2.20	do.....	1	151	40	200	8	18
A la Garonne.....	213	Horses, steam-tugs.....	2.20	do.....	2	130	30	150	139	70
Du Havre à Tancarville.....	25	do.....	3.50	do.....	9	22	925	90	17	5
Hasebroeck.....	25	Men, horses.....	1.30	Stony.....	20	187	8	800	43	48
Ille-et-Rance.....	85	Horses.....	1.62	Stony.....	1	46	8	800	16	20
Du Loing.....	50	Men, donkeys, horses.....	2	Stony, sandy.....	2	501	35	190	153	51
Lateral à la Loire.....	183	do.....	1.60	Stony.....	2	3	14	15	15	3
De Marais à la Roehelle.....	22	Men, horses.....	2	do.....	1	43	50	250	35	13
Lateral à la Marne.....	63	Horses.....	2	do.....	1	72	50	250	69	41
De la Haute Marne.....	77	Steam, horses.....	2.10	Graveled.....	5	734	151	250	145	113
De la Marne au Rhin.....	207	Horses.....	2	Stony.....	1	136	68	153	124	72
Midi.....	247	Horses, steam.....	2	Sand-d.....	7	159	68	153	126	238
De Nantes à Brest.....	360	Horses, men.....	1.62	do.....	4	213	240	375	21	4
Du Nivernais.....	174	Mules, donkeys, horses, men.....	1.50	Stony.....	4	37	505	300	127	116
Lateral à l'Oise.....	34	Horses.....	2	do.....	12	201	124	300	42	27
D'Orléans.....	74	Men, mules, donkeys.....	1.60	do.....	4	457	124	300	42	85
De l'Oureq.....	107.9	Horses.....	2	Stony.....	109	188	4	210	24	0
De Saint-Quentin.....	93	do.....	2	do.....	2	134	4	210	24	0
Du Rhône à Cette.....	98	do.....	2	do.....	2	188	4	210	24	0
Du Rhône au Rhin.....	190	Horses, men.....	1.80	do.....	2	188	4	210	24	0
De Roanne à Digoin.....	56	Donkeys, horses, men.....	2 to 1.50	Stony.....	2	188	4	210	24	0

A.—*French canal statistics*—Continued.

[Inclosure in Consul Rathbone's report.]

Names of canals.	Length.	Means of traction.	Depth.	Nature of towing-path.	Number of boats.		Horse power.	Maximum and average tonnage.	Bridges.	Flood-gates.
					Steam.	Not steam.				
Bonboix.....	<i>Kilos.</i> 22	Horses.....	<i>Mètres.</i> 2	.....	.....	63	.....	<i>Kilos.</i>	33	13
De la Sambre à l'Oise.....	67	do.....	2	.....	.....	95	.....	.....	29	38
La Sauldre.....	47	Donkeys, horses, men.....	1.50	Sanded.....	.....	16	.....	70	48	22
La Haute-Seine.....	76	Horses.....	1.50	Graveled.....	.....	2	.....	150	21	12
La Sausée.....	25	do.....	2	.....	1	103	60	200	13	3
La Somme.....	156	do.....	2	Stony.....	1	95	70	220	49	23

NORTH OF FRANCE.

REPORT BY CONSUL WILLIAMS, OF ROUEN.

THE DEULE.

The navigable water ways which have been constructed and utilized for transportation are very numerous in the north of France; most of them are very ancient. Since their early construction, they have been subjected to many changes. The following brief account of the construction of the canal of Deule will give an idea of what would be the magnitude of the work of describing all of the canals in this consular district. The Basse Deule has been navigable from time immemorial. It was conceded wholly to Lille in May, 1267, by Marguerite, Countess of Flanders and Hainaut.

On the 31st of October, 1271, John III, lord of Lille and La Bassé, was authorized at his own expense to construct a canal between these two cities. The act fixed the size at 40 feet with a depth of at least 4 feet, and allowed for the work a remuneration of 1,500 livres d'Artois*. This work upon 25 kilometres was completed within a year.

In the beginning of the sixteenth century this canal was extended to Courrières and Lens. This work was done at the expense of the city of Lille by an ordinance of the council of state of the king, dated October 31, 1674.

These different undertakings, although important, failed to attain any real commercial importance until the year 1688, when a project was entertained of uniting the valleys of the Deule and Scarpe by a canal which, passing over the ridge which separated them, would arrive at Courrières at the Fort of Scarpe.

The cost was equally divided between the city of Lille and the states of Flanders and Artois.

The 7th of May, 1696, the city of Lille undertook the entire charge of the work and collected the tolls.

On the 6th of August, 1749, a royal decree enjoined the excavation of the canal between Douai and Lille; this work cost 413,539 francs. At this time the junction was made in the passage of Lille, and the canal of Esplanade was opened, which was destined to complete an uninterrupted line of communication between Fort de Scarpe and Deulement. The canal of Deule became the property of the state after the Revolution in March, 1798.

Toll was established upon it in favor of the state in April, 1808.

Nevertheless, by an order issued in 1810, Lille was put to the expense of a cleaning out, which was done under the supervision of the Government by some Spanish prisoners at an expense of 600,000 francs. The city has never been able to recover this sum.

The Deule thus formed a canal at summit level. The highest level situated between the locks of Fort de Scarpe and that of Pont-à-Vendin (destroyed in 1859) was 20,400 metres long. It was fed by a spout of water taken from the Scarpe above Douai, through a little artificial stream. Navigation was difficult, even at a draft of water not exceeding 1.20^m, and intermittent on account of the dam at Pont-à-Vendin and the others below having but one set of gates. During the dry season navigation was closed.

* The ancient livres varied in each department from 20 to 26 francs.

The progressive filling up of the canal, as well as the difficulty of supply, continually increasing and becoming more serious, and the requirements of business developing itself at the same time, the Government, since 1820, has studied to improve this canal to the greatest extent of which its nature would admit.

The lock at Pont-a-Vendin was taken away and the bed of the canal lowered to the same point as that of the river Scarpe, thus transforming the canal into a branch of that river and insuring a good supply of water and the more rapid movement of boats.

Locks replaced simple dams, the depth of the canal was increased so as to permit the passage of boats drawing 1.5 metre of water.

By the law of March 24, 1825, there was a grant made. The cost to improve this canal was estimated at 1,200,000 francs. The demand upon the canal being still greater than its capacity, the parties holding the grant were obliged to do supplementary work, and it was only in 1837 that the proper depth and constant supply of water for the canal were obtained. The grant of the Deule, which was considered at first as quite unimportant, has paid its stockholders largely, and that under a moderate rate of toll.

The average tonnage of the whole route did not exceed 150,000 tons till 1825, but in 1853 it reached about 600,000 tons. The grant expired the 16th of September, 1854, since then other improvements have been made. The depth of the canal has been increased to 2 metres between Douai and Lille, by the decree of April 18, 1860, so as to permit the passage of boats drawing 1.8 metre of water. The expense was 534,633 francs. Another enactment made 3d of August, 1862, authorized the straightening of the canal through Lille. The cost was 643,913 francs. A new lock was constructed at Don in 1868, at a cost of 362,592 francs, but the improvements were still incomplete. The canal was crooked both above and below Lille, and did not have the full depth throughout its length.

By a new act in 1880, an appropriation of 3,418,800 francs was made to complete the canal according to the plan annexed to the law of the 5th of August, 1879—this work contemplating many important changes, such as a general cleaning out of the bed, protecting the steep banks with stone, the establishment of public ports, and sidings for placing boats, will when completed admit the passage of boats of 38.5 metres in length, 5 metres in width, and 1.90 metre of draft, carrying 300 tons throughout the entire canal, the same as those now plying between Paris and Lille.

The sums which have been spent upon the construction and improvement of the Deule, including those covered by the act of 1880, can be termed in round numbers as follows:

	Francs.
Previous to the nineteenth century.....	7,000,000
Grant Honorez, March 24, 1825.....	1,200,000
Act of April 27, 1860.....	534,000
August 3, 1862.....	744,000
September 10, 1868.....	366,000
August 3, 1880.....	3,418,000
Total.....	13,262,000

The cost per kilometre amounts to 207,000 francs. This expenditure is very moderate considering the results obtained, and the great advantages afforded by this route.

The canal of Deule in its most important and frequented sections, between Douai and Lille, has only two levels, the one of 30 and the

other 17 kilometres in length, separated by the lock of Don. Between Douai and Don, it presents alternately straight lines, or long curves.

The work in progress will remove the remaining short curves and narrow passages between Don and Lille, and between Lille and the head of the canal of Roubaix.

It traverses the principal industrial centers of the Department of the North and of the Pas de Calais. It serves for the transportation of coal from the mines of that section and its distribution at the principal centers of consumption; Paris at one extremity and Lille and Roubaix at the other.

It forms one of the lines which connect Paris with Lille and the northern ports, Dunkirk, Gravelines, and Calais.

The traffic of this line is large and increases yearly. Between Douai and Lille the tonnage passing over the whole route in 1882 amounted to 1,380,000 tons, and brought this canal to the seventh rank among the navigable waters of France.

It serves also a useful purpose in a sanatory point of view to Lille, a city of 178,144 inhabitants, and provides water for the interior canals of Lille and furnishes a supply of fresh water along its course. At the close of the eighteenth century, when the state became possessed of this canal, the flow of water was only 2,700 litres per second; it now exceeds 5,000 litres at the ordinary level.

This increase is due to the improvements above referred to, and the city is considered to be well repaid for her share of the expense incurred in the construction and amelioration of this canal.

Before leaving this branch of the subject of canals, contained in the query requesting the time and manner of their construction, I would state that the interior navigation of France is supplied with 11,855 kilometres of rivers navigable and smaller streams classed as capable of floating crafts, and 4,789 kilometres of canals. One would not care to reply categorically to the question, and give the exact figure of the time, manner, and cost of construction of each. As seen from the study of the canal of Deule, the net-work of navigable waters is the work of many centuries. The original streams have been transformed so as to have lost in many instances their normal character. These changes have been continually made to adapt them to the varying exigencies of the moment.

The depth, width, and dimensions of the works were made to conform to the progress of engineering as applied to the improvements in navigation.

New works thus replaced old works, so that, at a given moment, it is impossible to say how much remained of the old.

The cost of construction alone should be taken into account and separated from that of annual repairs. With this view, and in the effort to comply with this request, I have appended a chart containing the sums expended upon several canals at various times, many of them dating from the Gallic Roman period, passing the Feudal period, followed by a period when grants were conceded to corporations to construct and manage these canals, and the present period, when these canals have passed into the possession of the Government.

CANALS PRIOR TO THE SIXTEENTH CENTURY.

Before the sixteenth century and under the Roman rule, a few efforts had been made to build canals. Marius actually caused his legions to dig between Arles and the sea a canal to which his name is attached, but no vestige of the work remains.

The water courses were used for transportation, in a state of nature, and were navigated by small boats drawing but little water, and mounting a short distance from their sources. The roads were used to pass from one valley to the other. These water ways were the common property of the people inhabiting their borders, who used them freely, subject only to such restrictions as were required to respect the rights of one another, and refrain from damaging the property itself. As soon as the traffic became more brisk, an understanding was established between boatmen on such rivers as the Loire, Seine, Rhone, and Moselle, and certain regulations were established to define the rights of each one.

FEUDAL PERIOD.

At the time of the invasion of the wild hordes, boating was thoroughly disorganized. There was no safety for a long time in navigating the streams. The corporations of boatmen established a police among themselves and began to revive boating.

BOATMEN'S CORPORATIONS.

As soon as the royal power attained some strength the boatmen's corporations sought from it some aid to protect themselves from the lords. They obtained charters and had a regular organization and by means of assessments and tolls obtained the funds to carry out some improvements and alterations. At the beginning of the thirteenth century, such a corporation was in existence on the Seine. It was called the "Hanse des marchands de l'eau" or society of water merchants of Paris.

In the thirteenth century Philippe Auguste authorized them to build one of the gates of Paris (le port de l'école) and remunerate themselves by collecting a tax upon merchandise transported by water.

Analogous corporations rose up about this time upon the Garonne, Rhone, Saone, and the Loire. In 1402 the corporation called "des marchands navigateurs" (merchant navigators) of the river Loire received from Charles VI letters patent, by the terms of which the king conceded the right to them to collect during 4 years, taxes upon the boats and merchandise transported on the Loire, in order to enable them to resist the encroachments of the lords bordering upon the rivers. The collection of this tax was indefinitely postponed.

In 1482 an ordinance of King Louis XI decided that the receipts should be used to help in the maintenance and improvement of the Loire. This tax was called "droit de boëte" (old French for "box tax") because the collectors received it in boxes placed at the ports of the Loire. The ordinance of Charles VIII, of March, 1498, extended the appropriation of the "droit de boëte" to all of the rivers of the kingdom. The powers with which these corporations were invested by the king comprised, beside the right to conduct (even against the opposition of persons living on the borders) the cleaning of rivers, the removal of obstacles, and the construction and maintenance of towing paths.

It was found necessary that the Government should interfere to assist these corporations against the invasions of the lords, and to secure free use of the waterways to the people. Eventually these canals were made entirely tributary to the Government, which assumed the obligations incurred, and the construction of new and the maintenance of old works.

In the beginning of the sixteenth century a great impetus was given to interior navigation by the invention of locks. These appear to have been introduced by Leonard de Vinci under Francis I. The first attempts to utilize them upon the straits of the Lot, in 1527, were unsuccessful; but they were put into use upon the Vilaine from 1538 to 1575. Inclined planes without water had been previously used to effect the passage from one level to the other. Such planes existed in Flanders since the fourteenth century.

CANAL GRANTS.

To Henry the Fourth and his devoted minister, Sully, belong the honor of the attempt to construct a canal at summit level. In 1604 Hugues Crosnier of Tours, an engineer much in advance of that early period, was commissioned to prepare plans for the Canal of Briare, intended to connect the Loire and the Seine by the valley of the Loing. The royal treasury furnished the funds. Six thousand troops were employed upon the work. The death of the King soon after put a stop to this work. Political trouble and want of funds further postponed it for 30 years.

The enterprise was taken up again under the ministry of Richelieu. Guillaume Bouterone and Jacques Guyon were the authors of a new project laid before Louis XIII offering at their own expense to build this canal in 4 years.

Their offer and terms accompanying it were agreed to, and letters patent were issued in the month of September, 1638. The King conferred upon these men and their children titles of nobility. This canal was opened at the time specified.

The success of this first attempt of concessions led to their general adoption. For nearly three centuries the reign of concessions for canals prevailed, and was beneficial in the results of their development.

For the natural waterways the state held the control and received the tolls, furnishing, with the aid of the interested districts and localities, a more or less considerable balance of the funds required.

After the death of Colbert, in the reign of Louis XIV, grants of the rivers Eure, Loire, and Clain, were conceded to favorites. Others soon followed to the royal family or attendants at court.

CANALS DURING FIRST REPUBLIC.

Nearly all of the work upon canals was interrupted by the revolution.

The decree of January 15, 1790, which abolished provincial administrations, and divided France into departments, united in the public domain all navigable waters which belonged to the provincial states, six canals having only a length of 134 kilometres escaped.

The collection of tolls was abandoned on nearly all of the canals, and entirely upon the rivers, which were completely neglected.

The canals were at first placed in the hands of the agency of the national domain, from 1791 to 1798. From 1798 to 1807 they were intrusted to an administration in which the Government was interested.

As soon as quiet and order were restored, the repairs and maintenance of these canals, fallen into decay by the neglect of many years, became the object of solicitude to the Government.

Then came a law indicating a new departure in the way of specification of taxes and their appropriation to the maintenance of the canals.

The estimated cost of repairs at that time was 11,825,629 francs. These and many more provisions were made by the celebrated law of the 30th Floréal, year X (May 20, 1802). After having provided for the maintenance of each series of canals from their receipts, the Government took upon itself to continue the constructions interrupted by the revolution.

Contrary to the line of conduct adopted for the existing water routes, the proposed new lines were to be constructed at the expense of the Government. The funds were deficient. Napoleon then proposed to raise the necessary amount by selling the canals belonging to the state. These were the Midi, Orleans, Loing, and the canals of the Centre, and St. Quentin.

This plan was carried out by the law of the 23d of December, 1809, which ordered the sale of the above-mentioned canals upon the condition that the proceeds should be employed to finish the canal Napoleon, connecting the Rhine and the Rhone, the canal of Bourgogne, and the grand canal of the North, which was intended to unite the Escant and the Rhine. The proceeds, however, were diverted from the proposed channel and were swallowed up in the budget.

In the days of the Empire more than 1,000 kilometres of canal were projected but only 200 kilometres were opened to navigation. Seventy-five million francs were expended upon construction of new lines of interior navigation. The financial expedients resorted to during the period of 1789 to 1814 to meet the expenses and outlay for internal navigation were numerous.

Grants without being entirely abandoned were in disfavor. The regie or administration by tax for maintenance and repairs prevailed. The general funds were supposed to provide for the construction fund.

In the 25 years from 1789 to 1814, although the work ordered applied to 3,093 kilometres of canal, of which 1,202 kilometres were opened for traffic, it was impossible to appropriate more than 75,000,000 francs to this work, or about 3 millions per year, and the length opened up scarcely attained 200 kilometres, less than 10 kilometres per year.

SPECIAL APPROPRIATION OF TOLLS.

Some busy spirits during the reign of Louis XVIII, having discovered that the system adopted of applying the tolls of each water basin to its own maintenance not having succeeded, without investigating whether the defect was in the system or the manner of its execution, succeeded in changing it. The tolls were maintained but handed over to the treasury.

Recognizing its error, the Government again by act of March 24, 1825, placed the option within itself to specially appropriate the proceeds of each series of canals to themselves. For new constructions the Government confined itself to several financial expedients. Advances were wanted, and the Government contracted the loans by pledging the future tolls of the canals. These advances were made by the boards of trade, cities, or other interested parties.

This system has been productive of so much benefit that it seems unwise to condemn it, although the clashing of interest between the general and local authorities to which it must give rise, clearly indicates that serious difficulties are scarcely avoidable. In 1879 canals were classified and made subject to precise limits, and definitions from which they were not permitted to vary in the least.

The lines are designated as first and second class. First class must have at least the following dimensions :

	Metres.
Depth of water	2.00
Width of locks	5.20
Length of locks in the clear	38.50
Height under bridges	3.70

All rivers and canals not classed as principal lines are considered as belonging to the second class.

The most notable event of the same year was the abolition of all tolls upon the canals by a law which took effect October 1, 1880. It was impossible to resist the importunities of boatmen, especially after having discharged the railroads in 1878 from a tax of 5 per cent. upon merchandise transported. This law provided for the repurchase of grants of rivers and canals, but circumstances have prevented this part of the programme from being fully carried out.

The following lines were purchased:

	Francs.
Scarpe Supérieure	5,253,024
Canal of Vite and Saute	232,000
Canal Beaucaire and la Radelle	4,087,659
Canal of Givors	2,000,000

· GRANTS AND CONCESSIONS.

The situation of grants is as follows :

	Expiration of grant.	Area of grant.
		Kilometres.
Perpetual grants:		
Loz or Canal de Grave		10
Canal de Lunel		9
Canal du Midi		279
Canal de l'Ourey		108
Canal St. Denis		7
Canal St. Martin		5
Canal d'Aire	Dec. 3, 1850	3
Canal du Bourgidon	Sept. 22, 1839	11
Canal de la Dive et du Chouet	Jan. 10, 1925	40
Drot	Jan. 1, 1943	58
Canal from Dunkirk to Furnes	Sept. 10, 1899	13
Canal lateral à la Garonne	Dec. 31, 1960	213
Canal de St. Dizier à Wassy	—, 1948	23
Sambre canalisée	Oct. 6, 1890	54
Canal de la Sambre à l'Oise	Nov. 1, 1937	71
Canal de Sylvéral	Sept. 22, 1939	9
Canal de la Souchez	Sept. 31, 1950	3,400
		916,400

No new concession has been granted under the third Republic. The expenditure for the improvement of water ways of France from 1875 to 1887 derived from the treasury advances and local contributions were: For the rivers, 185,370,803 francs; canals, 249,713,581 francs; total, 435,084,384 francs. The State also appropriated to the reimbursement of advances a sum of 80,619,349 francs. The purchase of the grants of the Scarpe, Vire, and Tande, and canals of Beaucaire and la Radelle caused an expenditure of 9,319,659 francs.

CANAL STEAM NAVIGATION.

The hydraulic elevator has replaced five combined locks at the passage of the Tontinets upon the canal of Neufossé. Upon the lines from Paris to Lyons, by Bougogne and Bourbonnais, some portions of the

route are not yet finished, but the work on these is actively pushed and they will soon be finished.

The draft of water of 3 metres which has been obtained between Paris and Rouen has induced the formation of a regular line of service between Paris and London. The *Emily*, which can carry 173 tons, made twenty trips last year, carrying a little more than the half of this quantity of freight each way.

The *Lemington* made several trips between Paris, London, Cardiff, Plymouth, and Liverpool, carrying 112 tons, having a capacity of 208 tons. The *Esther*, of a capacity of 460 tons, made a trip carrying 335 tons.

These are simply huge canal boats propelled by a screw.

The proportion of traffic by steamers varies considerably according to the nature of the merchandise. Coal, building material, manure, wood, unwrought iron, and agricultural products, are carried by ordinary boats, either towed or by cable, while steamers carry principally machinery, groceries, and in general all valuable merchandise.

Some side-wheel steamers which ply regularly between La Villette and Rouen by the canal of Denis, of 125 to 200 tons capacity, vary from 20 to 70 horse-power and make three to four trips per month, while those which go to Corleil and other ports of Paris from Rouen, or Havre, are screw steamers with 200 horse-power and 300 tons capacity and make about 25 trips per year. These boats never take on a full load.

CENSUS OF CANAL BOATS.

A general census of boats engaged in the interior navigation of France took place October 15, 1887.

It was taken without interrupting the advance of the boats. The result was as follows:

Ordinary boats.—The entire number of boats upon the navigable waters of France was found to be 15,730, with a tonnage of 2,713,847 tons of 1,000 kilograms, corresponding to 1 gross ton.

Nine hundred and thirty-three boats of 38.5 metres* (126 feet 3 inches) and upward in length, having a tonnage of 342,933 tons.

Four thousand eight hundred and sixty-three boats of 33 metres to 38.5 metres in length, having a total tonnage of 955,010 tons.

Their nationality was found to be as follows:

Built in—

France	14,252
Belgium	1,017
Germany	339
Various nationalities, Holland and Alsatian	112

The ownership of the boats was as follows:

French boats	13,632
Belgian boats	1,645
German boats	280
Holland and the provinces of Luxemburg and Alsace	173

Most of these boats were constructed of wood; 858 only were of iron.

Of the 15,730 counted, 7,578 had decks and 8,152 were without decks. Nearly all (13,324) had cabins; 2,406 had none.

In these cabins 38,108 persons were sheltered, of whom 18,750 were men, 7,323 women, and 12,035 children.

The crews, including the owners, number 23,141 men, of whom 14,893

*A metre is 39.3708 inches.

were French, 3,248 foreigners—Belgians, Germans, Hollanders, and Alsations; 1,874 of these boats had stables, in which were sheltered 2,587 animals for towing the boats, of which 1,154 were horses, and 1,433 mules and asses.

There were found upon these waters 673 steamboats of a capacity of 45,865 tons, and 55,932 horse power. Two hundred and thirty-seven of these steamers were propelled by paddle wheels and 437 by screws. Two hundred and ninety-nine of these boats were used for carrying passengers, 120 for merchandise, 184 as tugs, and 70 for towing. In this list were included 38 steam-yachts, having a capacity of 562 horsepower. Only 61 of these vessels had a foreign origin. Of the owners, 634 were French, and 39 only foreigners.

The crew, captain, engineers, and stokers included, numbered 2,870 men, of whom 2,675 were French, 81 Swiss, 65 Belgians, 2 Germans, 35 English, 3 Spaniards, and 6 Italians, and 3 of whom the nationality was unknown. These boats came under the head of eleven groups, and in several of these groups were as many as from twelve to fourteen different styles of boats of all sizes, shapes, and varieties of construction. The principal types of boats in use are as follows: (1) *Péniches* or *belandres*. This is the most important group, and represents a third of the tonnage, and a much greater proportion of the boats navigating the Seine, and the canals of the north. They are flat-bottomed and decked. Their form is rectangular, their dimensions and tonnage are variable, but all of recent construction are of the regulation size of first-class boats, and the tonnage when drawing 1.80 metres varies from 295 to 300 tons. They are used for long routes. (2) The *thaland* so nearly resembles the *péniche* or *belandre* that they are often mistaken for them. They are used upon rivers and canals, and especially those of the north and east, and on the Seine. Those of the Seine are generally 40 metres in length and 7.35 metres in width, and carry 475 tons, drawing 1.8 metres of water. They are found even longer, 50 metres, and these can carry 625 tons. Each series of canals and each river has its peculiar crafts which seem best fitted to the locality. The capacity of these boats varies from that of the market boat to the boats found on the Rhone and Saone, which, with the same draft of water and a proportioned width of beam, have a length of from 120 to 140 metres. These long hulls, adapted to a special navigation, are really floating rafts, which on the rapids receive a perceptible inflection in a vertical direction.

Custom has adopted these exceptional dimensions upon the Saone, the course of which is smooth, as well as upon the Rhone, which is rapid in its flow. They seem to answer the purpose on both streams.

TOWING FROM THE BANK.

Towing from the bank or towpath is accomplished by men's arms or beasts of burden.

Upon the canals but little used, the towing by hand is still the most in use and is the most economical. Two men with allowance of or the difference of the load can draw a boat carrying from 80 to 100 tons. It is hard work, but when locks are frequent is endurable. The rate of travel rarely comes up to a kilometre (five-eighths of a mile) per hour, and with the time lost in locks, not more than 8 or 10 kilometres can be reckoned for a day's work. The cost of hauling alone is 5 to 7 millimetres (0.007 franc) per ton per kilometre. The use of the boat, insurance, incidental expenses, and profit, come to as much more, so that the cost

of transportation in this way is from 0.010 to 0.014 franc per ton per kilometre.

Upon the Canal de Berry, to pass through the narrow locks, boats of 2.50 metres in width, carrying 50 tons, are used. They are towed by an ass, stabled on board, assisted by the boatman and his family when circumstances require.

This primitive arrangement competes successfully with the large boats, not only on the larger canals communicating with the Canal de Berry, but also upon the small streams of the basin of the Seine. When the happy family are in accord, and everything moves smoothly, this mixed towing costs about the same as the first mentioned, while gaining two or three more kilometres per day.

Towage by horses is done at the rate of 14 to 18 kilometres per day; the price amounts to 0.011 franc, and the whole cost of transportation to 0.017 to 0.018. With relays of horses the cost would increase from 0.020 to 0.022 franc, and there would be a gain of 11 to 12 kilometres per day.

Many of the boats, like those of the Canal de Berry, carry their horses on board.

There are so many contingencies, such as flood, rates of insurance, pilotage, etc., which vary so much at different times and seasons, and are also influenced by a more or less lively competition, that the figures above named as the price of towing may rather be assumed as what they should be, than what they really are.

- COMPULSORY TOWING.

By an act of the 19th of June, 1875, towing was made compulsory upon the Escaut, the canal of St. Quentin, the canal of Senezé, the Scarpe, Deule, etc., in short upon all water ways which connect Paris with the north and Belgium. This commercial restraint became necessary on account of the frequent blockades upon routes where it was important to keep free passage. It has been satisfactory, but it would be injudicious to attempt to generalize a measure of this kind.

The arrangement is briefly as follows: A contractor on each division agrees to insure the towing of all boats which offer, at prices fixed in his contract, and which vary according to distance and the kind of towing required. Their prices average per kilometre 0.002 per ton of boat's hull added to 0.003 to 0.006 millimetres per ton of actual cargo. Towing is obligatory upon all loaded boats except steamers and sailing vessels; it is optional for empty boats.

CANAL SAILING VESSELS.

Sailing is very little practiced upon the interior rivers of France; numerous bridges and narrow connecting canals do not offer great facilities for this mode of navigation. In the maritime portions of the rivers, where bridges are rare, nearly all of the ships are equipped with sails, which they use advantageously.

STEAM NAVIGATION.

There are two kinds of steamers—those propelled by side wheels and those by screw.

The former, acting on the surface, require less draft of water and are not so much exposed to damage from bars or other obstructions in the stream; on the other hand, in the maritime part of the river they are sub-

ject to a rolling motion, which interferes with the action of the paddle boards and the steady stroke of the machinery.

The screw, always immersed and always in motion, is preferable and is almost entirely used upon crafts which approach the sea. Upon tidal rivers, where the deep and shallow soundings succeed each other, wheels are the safest. Upon rivers used as canals and canals of uniform depth the screw has the advantage that it is not in the way, as wheel-cases are in the locks, and only add an insignificant length to the boat.

The wheels have been placed astern so as in a measure to obviate this difficulty upon boats navigating the canals, but unless special conditions prevail upon the water way the screw is preferable. Steamers are used, being themselves laden, to tow one or two boats on canals, where the locks only admit one boat at a time. On rivers and double locked canals strong tugs, towing quite a fleet of boats, are employed

GRAPNELS OF THE RHONE.

There are boats of a particular construction found upon the Rhone called "grapins," fitted to pass over the shallows, customary in rapid streams. They are strong steamers with side wheels like the other Rhone steamers, having besides a strong plunging wheel made with iron teeth and turned by the machinery, which grapples onto the bed of the river and exert a great driving force. In sufficient draft of water the grappling wheel is not used, but in shallow water the plunging wheel is lowered 2 or 8 metres.

CABLE TOWING.

Towing is also done by attaching a boat to a submerged chain traversing the entire length of the canal, and by means of which and the aid of its engine it not only is towed, but a fleet carrying 1,200 to 2,000 tons and even more follows. Each boat is separated from the other by 25 metres.

The price for the use of this cable is a centime per kilometre, with a proportionate deduction for long distances. This mode of towing has proved very successful in tunnels.

It is in use at Paris, on the canal St. Martin, the canal St. Quentin, and the canal of Bourgogne. More recently it has been applied to the canal of Marne on the Rhine and to the tunnel of Maurages.

Boats are passed by alternate convoys from each direction, and the engines consume their smoke. In Belgium an attempt has been made to substitute steel for iron in the cable in the hope of making it more convenient and lighter. This lightness, advantageous in certain ways, is objectionable in others, and seems to have been abandoned. For instance, in curves it is well that the chain be heavy, so that the stretch in advance of the boat should be as short as possible, as thus the convoy is less forcibly drawn towards the Coubex bank.

CANAL VS. RAILWAY TRAFFIC.

It is only necessary to glance at a comparative statement of the traffic upon canals and railroads to become convinced of the effect of the former in not only cheapening the price of transportation, but providing an outlet for coal, minerals, etc., which would otherwise remain unmarketable.

In 1885 the railroads, like very sensitive barometers, indicated the depression of trade by their diminished receipts, which were 10 per cent. less than those of the previous years.

Their total receipts remained stationary from 1880 to 1886, although in this interval the length of the lines had been extended from 23,089 kilometres to 30,696, or an increase of about one-third. The tonnage was even more affected than the conveyance of passengers.

From 1884 to 1885, although 1,123 kilometres of new line had been opened, say 4 per cent., the tonnage fell from 10,487,996,453 to 9,791,537,635, a loss of 7 per cent. The crisis, which so unfavorably affected the railways, had the effect upon the canals of greatly increasing their traffic, as shown by accompanying chart. In examining the figures in canal freight in 1885 to 1887, it is seen that the tonnage of the navigable water ways rose during that period from less than 2½ milliards of tons to more than 3 milliards, gaining more than 20 per cent.

Upon railroads the cost of transportation is known and can be reduced upon full carloads to 4 and even 3 centimes per ton per kilometre on French railways.

Upon canals and rivers used as canals the price of transportation is unknown. It has been estimated at 15 millimetres for canals and 20 millimetres for rivers, which, with the keeping in repairs, represents 20 to 25 millimetres.

This estimate has been made for the North of France, where much is favorable to navigation. It can be assumed that less favorable circumstances could scarcely add more than 10 millimetres to this cost.

Adopting this estimate, which appears liberal, the benefit would be 1 franc for a course of 100 kilometres, and for a long route 3 francs for 300 kilometres.

It should, however, be considered that between two places united by railway and canal the former has an advantage of about one-fourth in distance. Valuable merchandise requiring rapid transit, such as wines, worth 350 to 400 francs per ton, would on a distance of 300 kilometres gain 2.25 francs, or one-half per cent., which would not compensate for the delay of a month. Coal, on the other hand, worth 15 francs per ton at the mine, by saving 2.25 francs would have a benefit of 15 per cent. The same applies to building stone.

The advantage upon rubble and grindstones which pay 6 francs by the cubic metre, the equivalent of 3 francs per ton, for a distance of 100 kilometres is 0.75 francs or 25 per cent. on cost of material. Wood, minerals, manure, limestone, bulky merchandise, hay, straw, and coke are advantageously carried on canals.

Heavy ordnance for the navy is often carried by canal, the risk of breaking down the cars and bridges deterring from the transport by rail. Agriculture and trade are particularly developed in the Department of the North, and of the Pas-de-Calais, and they owe much of their prosperity to the connection of their mines with the manufacturing centers of France by canals. This is the most important coal basin in France; it furnished in 1882 half of the whole amount mined in France, and more than 30 per cent. of the entire consumption of France.

The coal basin of the north and the Pas-de-Calais produced—

	Tons.
In 1850	1,000,000
In 1860	2,000,000
In 1870	4,000,000
In 1880	8,500,000
In 1884	9,500,000

In the year 1883 the output exceeded that of 1884 by 500,000 tons, as the industrial crisis limited the demand in the latter year.

The mining of this coal increases in a wonderful manner and calls for constant amelioration and increase of water communications, which can alone enable them to compete successfully with importations from other regions.

EXPENSES OF WATER WAYS.

The expenses of public water ways are, like other public works, subject to ordinary and extraordinary expenses. The first are of annual occurrence and do not vary much from year to year, such as keeping in order old or constructing minor new lines; the second relate to more permanent improvements and additions, which when complete do not require to be renewed for many years.

The first are included in the ordinary budget of the minister of public works; the second, under one or more heads, are termed extraordinary works.

Herewith will be found a summary of the ordinary expenses of the navigable ways, and another table of the sums thus expended from 1814 to 1817. These tables only give the details of the expenses for labor, to the exclusion of the laborers. The personal expenses paid for supervision are difficult to obtain, such as the sums paid to engineers, managers, secondary agents, lock-tenders, etc. Many of the superior officers and their aids have a variety of duties to perform which are not connected with canals. They have to look after roads, railroads, hydraulic works, and various surveys.

A considerable portion of this fund is applied to expenses connected with these water ways, such as maritime canals and the maritime portion of the river upon which ships ascend. The rivers serve other purposes, such as reservoirs for man and beast and domestic purposes and irrigation of the streets of villages and cities and irrigation of land. For the last-named purpose this district has no use. A considerable source of revenue arises from the sale of forests planted on lands redeemed by dikes and the banks of canals and upon which trees, principally willows and poplars, are grown, which sell on an average at 20 francs apiece at the growth of 30 years.

The revenue from this source alone was 345,063 francs in 1887. The wood sales of the navigable waters of the Department of the North and Pas-de-Calais were, from 1883 to 1887, 69,500 francs, and will be much more when the growing groves will be matured. The net profit of the sale of 18,000 poplars on the Seine was 414,000 francs in 40 years, or 10,350 francs per annum. The trees add not only to the beauty but the comfort of these water ways.

The falls are utilized as a motive power, and they become vast reservoirs, where fish are extensively propagated. They sometimes break through their banks and do much damage to lands and become the depositaries of much unhealthy matter and require great outlay for repairs.

The importance of the water ways of France is conceded on all sides, and their extension and amelioration have received the careful consideration of every administration, and of none more than the present.

The financial problem alone prevents their more rapid completion. France must (or thinks that she must) maintain an immense army and navy, and these cry louder than canals for their supplies. Profits drawn by the State from the navigable water ways still exist, as shown by the tables, although tolls have been abolished.

Those which accrue to the state, as regulated by decrees, from the extension of the dikes of the lower Seine, deserve particular mention. The share of the state is one-half, the other half of the land reclaimed in this way becoming the property of the owner adjoining the river.

The work is far from complete, yet 20,000,000 francs' worth of land can now be considered as already acquired. In addition the treasury has already received 3,660,000 francs from the sale of grass. Although tolls no longer exist, it is interesting to examine, as in an accompanying table, what these were from their commencement July 9, 1836, until their abolition in 1879.

The fluctuations from year to year were due to changes in the tolls and are no index to the amount of traffic.

CONCLUSION.

It is only a question of money to render Paris as accessible to the sea as any European port, and to connect it with Dunkirk on the northern coast by a deep canal, and to unite the Mediterranean and the Atlantic by a ship canal.

The water ways of our own country have presented such great natural advantages that their extension and improvement for navigation has been too much neglected. Our lakes could be readily united by a ship canal with the Hudson, and Albany (if Troy would permit) could, if connected by a ship canal with the city of Hudson, receive the largest ships, which would greatly relieve the docks of New York. The requirements of Western freight will soon demand some such arrangement, and the only relief will be through Canada, which is already making great strides in that direction.

The efficient body of engineers who have visited France this season have been much interested in the study of the utilization of the navigable ways, and their influence will be felt in improving the numerous water ways of every section of our country.

It is well to anticipate the requirements of our country, which will soon have outgrown all of the railways and canals, and should not be retarded in its progress while awaiting other constructions and extensions.

REVENUE AND EXPENDITURES.

The accompanying tables show the expenditures for maintenance, and the receipts from tolls from 1814-'30 to 1879-'87, for all France.

ORDINARY WORK.

Expenses drawn from the treasury and from other interested sources.

Years.	Treasury funds.			Funds from other sources.		
	Rivers.	Canals.	Combined.	Rivers.	Canals.	Combined.
	<i>Francs.</i>	<i>Francs.</i>	<i>Francs.</i>	<i>Francs.</i>	<i>Francs.</i>	<i>Francs.</i>
1827.....	5,269,000	5,638,000	10,807,000	213,000	26,000	239,000
1814-'30.....	33,608,199	.....	33,608,199	.....	.....	.....
1831-'47.....	102,153,999	38,851,956	141,005,957	.....	.....	.....
1848-'51.....	27,715,381	16,841,594	44,556,975	79,180	70,601	200,302
1852-'70.....	117,034,805	89,798,202	206,833,007	5,834,616	530,488	5,865,104
1871-'78.....	39,198,527	36,843,851	76,042,378	1,629,188	246,671	1,875,859
1879-'87.....	46,155,927	46,597,578	92,753,505	2,364,651	812,398	2,677,040
Combined.....	365,866,838	230,933,183	596,800,021	9,458,156	1,160,158	10,618,314

ORDINARY WORK—continued.

Expenses drawn from the treasury and from other interested sources—Continued.

Years.	Funds of treasury and other funds combined.		
	Rivers.	Canals.	Combined.
	<i>Francs.</i>	<i>Francs.</i>	<i>Francs.</i>
1887	5,482,000	5,482,000	11,046,000
1814-'30	33,608,199	33,608,199	33,608,199
1831-'47	102,153,999	102,153,999	141,005,957
1848-'51	27,845,082	27,845,082	44,757,277
1852-'70	122,369,421	122,369,421	212,698,111
1871-'78	40,827,715	39,090,522	79,918,237
1879-'87	48,520,578	40,909,976	95,430,554
Combined	375,324,994	232,093,341	607,418,335

EXTRAORDINARY WORK.

Expenses incurred for interior navigation.

	Rivers.							
Years.	First category.	Second category.	Special credit.					
			Rhône.	Saône.	Teŕro.	Rhin.	Loire.	Allier.
	<i>Francs.</i>	<i>Francs.</i>	<i>Francs.</i>	<i>Francs.</i>	<i>Francs.</i>	<i>Francs.</i>	<i>Francs.</i>	<i>Francs.</i>
1887.....	3, 859, 000	1, 365, 000						
1814-'30	33, 608, 199							
1831-'47	22, 697, 384	28, 283, 104	10, 646, 562	5, 410, 454	1, 516, 775	6, 772, 499	12, 505, 693	1, 284, 413
1848-'51	5, 613, 565	4, 971, 206	5, 114, 790	1, 391, 721	569, 719	3, 352, 597	3, 126, 127	359, 622
1852-'70	33, 136, 914	23, 760, 160	12, 917, 640	6, 638, 889	3, 601, 573	15, 210, 262	10, 924, 370	1, 582, 953
1871-'78	17, 701, 814	7, 394, 137	3, 458, 682	2, 092, 193	1, 257, 103		3, 912, 932	509, 154
1879-'87	35, 846, 387	9, 664, 301						
	222, 677, 171		32, 137, 674	15, 532, 767	6, 944, 170	25, 335, 368	30, 469, 122	3, 736, 142

Years.	Rivers.				Canals.			Total.
	Special credit.		Ferries.	Combined.	First category.	Second category.	Combined.	
	Sevre niortaise.	Garonne.						
	<i>Francs.</i>	<i>Francs.</i>	<i>Francs.</i>	<i>Francs.</i>	<i>Francs.</i>	<i>Francs.</i>	<i>Francs.</i>	<i>Francs.</i>
1887.....			45, 000	5, 269, 000	4, 450, 000	1, 088, 000	5, 538, 000	10, 807, 000
1814-'30				33, 608, 199				33, 608, 199
1831-'47	961, 261	12, 075, 854		102, 153, 999	27, 849, 392	11, 002, 566	38, 851, 958	141, 005, 957
1848-'51	276, 457	2, 402, 767	537, 870	27, 715, 381	11, 555, 980	5, 285, 614	16, 841, 594	44, 556, 975
1852-'70	1, 459, 625	5, 804, 735	1, 998, 184	117, 034, 905	67, 585, 109	22, 213, 093	89, 798, 202	206, 833, 007
1871-'78	380, 292	1, 801, 873	690, 847	39, 198, 527	30, 833, 728	3, 010, 122	38, 843, 851	78, 042, 378
1879-'87			645, 239	46, 155, 927	37, 038, 965	9, 558, 613	46, 597, 578	92, 753, 505
	3, 077, 635	22, 084, 669	3, 872, 140	365, 866, 838	174, 863, 175	56, 070, 008	230, 933, 183	596, 800, 021

Digest of revenue and profit accruing to the state for rivers and canals in 1887.

	Rivers.	Canals.	Total.
	<i>Francs.</i>	<i>Francs.</i>	<i>Francs.</i>
Ferries	89,668	2,226	91,894
Fishery	831,343	189,596	1,020,939
Landing	111,466	159,322	270,788
Plantations	27,203	317,660	345,063
Use of water	62,487	77,505	139,992
Use of public domain	129,314	94,236	223,550
Contract for towing	3,769	192,802	196,571
Miscellaneous	94,046	51,108	145,154
Total	1,349,296	1,084,655	2,433,051

Annual income from canal tolls received by the state for years 1838 to the abolition of tolls in 1879.

Year.	Annual income.	Year.	Annual income.
	<i>Francs.</i>		<i>Francs.</i>
1838	5,013,316	1859	7,071,179
1839	5,477,098	1860	6,597,133
1840	5,280,861	1861	4,096,050
1841	6,794,861	1862	4,259,020
1842	6,585,821	1863	4,832,903
1843	7,004,282	1864	4,977,166
1844	7,002,055	1865	4,871,249
1845	8,726,090	1866	5,379,476
1846	9,144,401	1867	3,826,188
1847	9,074,623	1868	3,721,624
1848	6,806,356	1869	3,064,408
1849	8,028,395	1870	2,072,668
1850	9,387,796	1871	3,283,479
1851	10,359,129	1872	2,777,225
1852	10,682,484	1873	3,705,276
1853	10,682,484	1874	3,842,490
1854	9,556,109	1875	4,270,869
1855	10,399,559	1876	4,154,626
1856	11,008,348	1877	4,402,226
1857	10,584,528	1878	4,293,813
1858	7,892,782	1879	4,390,781

CHAS. P. WILLIAMS,
Consul.

UNITED STATES CONSULATE,
Rouen, September 21, 1890.

THE FOREZ CANAL.

REPORT BY COMMERCIAL AGENT MALMROS, OF ST. ETIENNE.

The Forez Canal, derived from the Loire River, is destined to the irrigation of that part of the plain comprised between the Loire and the Lignon Mountains. It is composed of three great branches giving origin to a large number of arteries. By the decree of 1863 a perpetual concession of the canal was granted to the department of the Loire for the irrigation of about 65,000 acres, and granted for its construction 1,000,000 francs, representing about a quarter of the total expense. The works were thereupon commenced, but after some months, the subscriptions being deemed insufficient, the construction was interrupted for a long time. However, in 1882 a bill was passed assuring the complete execution of the canal at the expense of the state by means of the

following resources: First, a supplementary subsidy of 1,222,000 francs, bringing up the state grant to a third of the whole cost; second, a loan to the department of the Loire bearing interest at 4 per cent.

The maintenance and working of the canal should be borne by the department who each year was to hand over to the treasury the net proceeds until the whole sum advanced was paid off. Immediately the works commenced again and at the end of six years the three branches were terminated to the satisfaction of all parties and especially of the farmers who dwell in their vicinity.

Expense.—The expense of the construction of the Forez Canal reached the sum of 7,037,100 francs. The following table shows the lengths, area covered, and expenses of the construction at the different epochs:

Designation of the parts of the canal.	Area furnished.	Length of canal.	Expense.
	<i>Acres.</i>	<i>Miles.</i>	<i>Francs.</i>
Works executed before 1888.....	18,000	100	3,000,000.00
Works executed up to 1888.....	5,000	15	1,097,068.57
Total.....	23,000	115	4,097,068.57

The correct estimate of the remainder has not yet been ascertained as the canals are not yet completed, but it is expected that the whole sum will not exceed the 7 millions already mentioned.

Working of the canal.—The maintenance and working of the canal is done by the department of the Loire, which employs a regular staff of engineers, overseers, etc., for that purpose.

The sale of the water.—The water of irrigation is sold by volume and gauged with precision. The unit of subscription corresponds to a continual output of half a litre per second. The water can be employed for any extent of land and destined to other uses than that of irrigation as may be required. Nevertheless the subscriptions are based on the acreage. The lowest subscription which forms the unit is 40 francs. The water for public fountains or industrial uses is paid at 160 francs per litre.

Mode of distribution.—Some proprietors, and those amongst the largest consumers, take the water continually by special pipes, but by far the largest number receive it periodically and collectively. The members of these groups are served through the same pipe placed at the head of a stream, branching out into secondary rills so as to bring the water to the limits of each farm. The pipe is furnished with a flood-gate and a gauging apparatus, attended by a man who regulates the opening so that each rill receives the volume of water required. Each of the members of the groups receives once a week, the same days and at the same hours, the totality of the outflow during a time which is always in proportion to the importance of his subscription. For this purpose the proprietor places on the rill at the head of his farm a sluice which he opens and shuts at will. The irrigation commences on the land the farthest off from the canal, and when the time is up the proprietor behind closes the rill and turns the water on to his own land and so on until the farm nearest the parent canal is served, so that no fraud can be committed, or very rarely so. Thanks to this organization the surveillants have very little trouble, and in any case frauds are easily discovered.

Irrigation tables.—Each year before the 1st of April the irrigation tables are made out by the agents of each subdivision and posted up in

the mayors' offices until the 1st of November. Besides each subscriber receives a table containing the days and hours of the irrigation of every piece of land he possesses. The irrigation is arranged in such a manner that the very smallest proprietor receives the water at least two hours, and the volume distributed ranges from 7 to 15 litres per second. Night service is avoided as much as possible.

Methods of irrigation.—The waters of the canal are used almost exclusively for the irrigation of artificial or natural pastures.

Procedure.—First. Irrigation by horizontal rills for lands having a certain gradient. Second. Irrigation by wooden troughs, which is well suited to very flat lands.

Both of these methods are used with great advantage by the most intelligent of the farmers, but it must be said that many employ the water without care or discernment. The rills are irregularly traced and give out the water unequally, and manure is very sparsely employed. The stagnation of the water in the lower parts of the lands favor the growth of marshy weeds; but this comes from the fault of the proprietors, who neglect to fill the hollows or holes and give a regular slope to the meadows. However, they are beginning to do better as they gain experience.

Results of irrigation.—The results obtained by the conscientious proprietors are very satisfactory. Some lands for which 2,500 francs the hectare (2.471 acres) was paid before this system of irrigation are now worth 8,000 francs. The results for others are more modest, yet still encouraging. Meadows which heretofore were valued at 2,000 francs would not now be sold under 4,500 francs. As it takes from 500 to 600 francs per hectare to create a good meadow, the profit is then nearly 2,000 francs and due to irrigation. The hire of farms has also notably increased; lands which were let at 90 francs before the existence of the canals now obtain easily 200 francs.

Development of the system of irrigation from 1871 to 1885.

Years.	Length of canal.	Extent of irrigation.	Production.
	<i>Kilometres.</i>	<i>Hectares.</i>	<i>Francs.</i>
1871.....	31.940	211	8,435.30
1872.....	31.940	185.25	6,833.50
1873.....	32.96710	106.70	4,335.34
1874.....	38.78310	211.44	10,048.11
1875.....	38.78310	284.91	12,081.11
1876.....	68.17012	307.70	18,512.46
1877.....	63.17012	363.33	15,703.10
1878.....	79.64347	380.60	16,963.90
1879.....	85.17466	408.35	17,623.82
1880.....	96.28595	506.49	18,851.39
1881.....	102.32815	549.75	20,050.53
1882.....	104.00935	568.40	20,634.23
1883.....	104.00935	533.70	20,337.04
1884.....	104.09935	553.50	21,026.03
1885.....	104.69285	611.80	22,613.54

1 kilometre = $\frac{1}{2}$ mile.

1 hectare = 2.471 acres.

The slow progress of irrigation remarked in the plain of the Forez is to be attributed to the want of initiative on the part of many proprietors and to the relative importance of the expenses to be incurred in the preparation of the lands which hitherto did not receive the waters of the canal. It has been already stated that the cost by hectare amounted to 500 or 600 francs, and farmers hesitate to lay out that sum, although they are convinced of the profits they would gain, while again

the farmers have generally only a lease of from six to nine years, and consequently do not care to undergo much expense as they have such a short time to enjoy it.

The amount of water to be derived from the Loire is fixed at 5 cubic metres per second with permission to increase this quantity progressively up to 15 cubic metres. For the purpose of determining the sections of outflow of water 10 cubic metres have been taken as basis. On the 1st day of April, 1889, 160 kilometres 846 metres of the canal were in activity, of which 37 kilometres 35 metres belonged to the main canal, the remainder to the branch arteries. The entire work is in a sound condition. However, the impermeability of the canal and its branches leaves at certain points much to be desired. The filtrations of water thereby produced constitute not only a danger to the stability of the embankment at such points, but have also the inconvenience of greatly reducing the net revenues of the canal. It is proposed to devote all surplus revenues of the canal to remedy this defect. Although the advantages of irrigation in the Plaine du Forez are incontestable the receipts have but feebly increased.

From 1871 to 1885, inclusive, have been given in preceding table. Since then they have been as follows:

	France.
1887	24,928.37
1888	27,307.43
1889	29,000.00
1890 (estimated)	30,000.00

Secondary branches are constructed whenever the subscriptions in a region are sufficient to guarantee a revenue of 60 per cent. of the capital of construction. The probable expenses during the year 1890 will be 28,050 francs, leaving a surplus of 1,950 francs.

DEPARTMENT OF THE LOZÈRE.

In this department there is no irrigating canal constructed or owned either by the state or any of its subdivisions or by any private incorporated company or syndicate, yet believing that irrigation as practiced in the department and the laws regulating it may be of some interest, I submit the following remarks in regard thereto:

Up to the present, a special account of the lands irrigated in the department of the Lozère has not been kept. The lower valleys are generally irrigated as well as the sloping lands, and the quantity of hay and straw derived from grounds thus irrigated has increased fourfold and the quality has also been considerably ameliorated. The average price of land submitted to this irrigation has increased 4 and 5 per cent.

Sources of water supply.—No river, lake, or reservoir of importance exists in the department, but some rather good streams traverse in different directions the country and are availed of by the most intelligent farmers.

Character of works.—The method generally adopted in the Lozère consists in cutting through the banks of the streams and causing the water to flow through the land by rills slightly inclined. As the amount of water depends on the flushing of the streams by the rainfall it often happens that in summer a great lack is experienced. In such cases the proprietors of the soil have an understanding with each other and irrigate alternately. The water derived from springs is collected in reservoirs and distributed by means of pipes made *ad hoc*. The trac-

ing of the rills is very simple. The farmer cuts one from the stream direct and prolongs it to the end of his land and then traces arteries on each side of it as becomes necessary.

Water distribution.—The administration of the department has not so far regulated by any special laws the system of irrigation in the Lozère, but has left it entirely to the people themselves, who are governed by the general laws of irrigation, which are as follows :

The proprietors of land bordering on a running water other than such as belong to the public domain (state) may make use of such water for irrigating their land. In case the water runs through the property the owner may even within the limits of his land divert such water from its natural course for purposes of irrigation, provided it is restored to its natural course at the point where the water again issues from his property.

The proprietors of an estate traversed by a running stream can not absorb entirely such waters to the prejudice of lower riverside owners, even if such water does not suffice for the complete irrigation of his own estate. In such a case it belongs to the province of the local courts of justice to so regulate the use of said water between the several riverside owners as to conciliate the general interest of agriculture with the rights of private property.

The prefects of departments are invested with powers of making police regulations concerning the manner of using all running waters not navigable nor floatable. Every proprietor who in order to irrigate his land desires to make use of either natural or artificial water courses of which he has the right to dispose may obtain the passage of such water across intervening estates on first paying a just indemnity to the owners of the last-named estates. Excepted from this servitude are houses, roads, gardens, parks, and inclosures belonging to dwelling houses.

The owners of land lying below the estates so irrigated are bound to receive the waters running off from the latter on receiving a just indemnity. The exceptions mentioned to the previous apply also to this servitude.

The contests arising out of said servitude, the location of the pipes or other waterways, the dimensions and forms of the latter, the indemnities due to either the proprietors of said intervening estates or of the estates through which the water runs off from the irrigated property, have to be submitted to the tribunals of justice. These will proceed in a summary manner, conciliating the interests of the irrigating works to be established, with the respect due to property, and appoint, in case a valuation should be necessary, an expert, but not more than one. Riverside owners of land entitled to irrigation have the privilege of supporting their dams or other structures required for that purpose on the land on the opposite side of the river by paying a just indemnity to the owner of such land.

The peasantry therefore being completely free to control the irrigation of their lands they use the water according to their wants. Irrigation is effected at three different periods of the year: (1) Before the first cut; (2) immediately after, and (3) in September before the cold sets in.

The method of irrigation as given above, being so simple and rudimentary, it is difficult to calculate the expense, which in all cases is excessively small if not insignificant. The farmers trace the rills in winter when they have nothing else to do. The springs belong to the proprietors of the lands in which they are situated, and the streams belong to nobody in particular, but all who live on their borders possess the right of use of them as defined by the civil laws already cited.

Climate and soil.—The Department of the Lozère is the most elevated of the central departments of France. It is traversed in different directions by lofty mountains with profound valleys intervening. The winter consequently is rigorous to an extreme degree on the heights. The snow makes its appearance early in the month of October and does not disappear before the first fortnight in May. Parts of the country are rendered uninhabitable by the frequent snow storms which beat with fury the heights. In the valley the climate is cold in winter and not warm in summer except at the southern part of the department.

The nature of the soil is variable, but is for the most part chalky and granitic.

Rainfall.—The average rainfall in three different sections of the department is as follows:

Meude (chief town)	millimetres..	733=2 feet 1 inches
Marvejols.....	do.....	848=2 feet 10 inches
Villefort.....	metres..	2=6 feet 8 inches

OSCAR MALMROS,
Commercial Agent.

UNITED STATES COMMERCIAL AGENT,
St. Etienne, June 10, 1890.

COGNAC.

REPORT BY CONSUL EARLE.

There are no canals nearer than 100 miles distant from this consulate. It was once projected to dig a canal down the valley of the Charente. So little was found in favor of this scheme, however, and so much against it, that it was very properly dropped. At present the entire water transportation in this consular district is by the natural waterways. It is effected by lugger and schooner-rigged boats, furnished with folding masts, and having a capacity of from 75 to 150 tons of burden. These, as a rule, are maneuvered by a couple of tug boats belonging to a syndicate of lugger owners. I am unable to say how the freight rates by river and rail compare, but as a matter of fact, over two-thirds of the carrying trade of Cognac is by the Charente.

The nearest canal to this consulate is the great lateral canal of the Garonne, and of the Medi. This canal extends from the town of Castets in the Department of the Gironde, not far from Bordeaux, in a southeasterly direction to the town of Cette in the Department of Hérault. It begins, therefore, in the district of the consul at Bordeaux, and end in that of the consul of Marseilles. As these gentlemen will, therefore, give you all necessary information on this subject, I content myself with saying that this canal promises to be the most important in France. It is proposed to broaden and deepen it so as to make a ship canal from the mouth of the Gironde River to the Mediterranean Sea, thus obviating the necessity of passing through the Strait of Gibraltar. It is said that associations, unions, and companies have been formed and are forming for this purpose.

For the details and statistics of the above, however, I shall have to refer you to the consuls at Bordeaux and Marseilles.

EDWARD P. EARLE,
Consul.

UNITED STATES CONSULATE,
Cognac, August 14, 1889.

HAVRE.

REPORT BY CONSUL DUFAIS, OF HAVRE.

The canals in my consular district, embracing the arrondissements of Havre and Yvetot in the Department of the Seine-Inférieure, the Departments of Calvados, Ille-et-Vilaine, Manche, Mayenne, and Orne, are the following:

1. The canal of Tancarville, from Havre to Tancarville (on the Seine).
2. The canal from Caen (Calvados) into the sea at Ouistreham.
3. The canal from Rennes (Ille-et-Vilaine and Côtes du Nord) to the mouth of the river Rance, near Dinan.
4. The canal from Coutances (Manche) to the sea.
5. The canal Vire and Tante, connecting the town of Les Ornes on the river Tante with Porribet on the river Vire (Départ. de la Manche).

CANAL OF TANCARVILLE.

The danger to small river craft in navigating the lower Seine, and particularly its estuary, necessitated the construction of this canal. Its length is about 18 miles, connecting the docks of Havre, through the Bassin de l'Eure, with the river Seine at Tancarville, where the river contracts and becomes safe for river navigation; the work was finished and inaugurated on the 27th July, 1887.

The soil through which the canal passes being mostly alluvial, the cutting presented very little difficulty. The excavations amount to about 5 million cubic meters.

The canal emerges from the Bassin de l'Eure about five-eighths of a mile from this point; it bends to the northeast on a curve of about 650 yards; it then crosses the plain of Gravelle St.-Honorine diagonally, passes in front of Harfleur to within five-eighths of a mile of this town (to which there is a branch of the canal), and, following a curve of about 3,260 yards, strikes the foot of the cliffs of Gonfreville, Orcher, Roger-ville, Oudalle, and Sandouville up to the light-house of Le Hode, from whence it reaches Tancarville in a straight line through the meadows of St. Vigor, Cerlangue, and Tancarville, where it joins the river Seine at the foot of the Cape of Tancarville, about 60 miles below Rouen.

As said, a branch perpendicular to the line of the canal connects it with Harfleur, to which the depth of water is $19\frac{1}{2}$ feet; from Harfleur to Tancarville, $11\frac{1}{2}$ feet; its width from Havre to Harfleur, 62 feet, and from there to Tancarville, $81\frac{1}{2}$ feet.

The normal level of the canal is $3\frac{1}{2}$ feet below the mean level of the land between Havre and Tancarville, or $24\frac{1}{2}$ feet above the zero of the water of the charts of Havre.

At Havre steamboats and vessels pass from the Bassin de l'Eure into a "sarage" or receiving basin 163 feet in width, 750 feet in length; from there into a locked basin or "sas" 587 feet long and 98 feet wide through two double gates, from which they emerge through another like gate into the fluvial basin 196 feet wide, and 1,900 feet long. At Tancarville, where the springtides and accompanying bar reach an extraordinary height, there is a single gate (32 feet in height from the bottom), and another one of 30 feet in height forming a lock of 176 feet in length. The depth of water at the first gate at the lowest ebb is $10\frac{1}{2}$ feet, and at the lowest high tide 22 feet. From the lock vessels pass

into the "sas" or locked basin 587 feet long and 98 feet wide; then through two more gates respectively 25½ and 24 feet in height into the sarge or receiving and stationing basin and finally into the canal having a width of 81½ feet.

Nine turning bridges, operated by hydraulic power of forty-eight horses each, and several ferries cross the canal at convenient points; a telegraph line furnishes the service.

The canal is managed by the State, under the ministry of public works, by the administration of roads and bridges (Ponts et Chaussées). No tolls are levied.

The masonry of the locks, etc., is of the most solid description, being granite.

The cost of the canal so far has been about \$4,640,000, the original estimate of \$3,900,000 having been somewhat exceeded, principally in consequence of speculation having taken hold in anticipation of appropriation of necessary land to the extent of about \$254,000, and also to a change in the original plans regarding the depth of water from 17½ to 19½ feet, another width of the canal from 42 feet 4 inches to 52 feet, and also to some minor items.

Of the expenses, the Department of the Seine-Inférieure bore about \$206,400, and the Chamber of Commerce of Havre \$1,000,000. The remainder fell upon the State.

The principal localities which at the time of the opening of the canal were in active relations with Havre downstream were the ports of the Seine, Paris, and Rouen, and Nancy and Épinal, Sommerville, Meurthe, and Moselle, which sent cargoes of salt. Up-stream the principal goods were grain of all sorts, cotton, dyewoods, petroleum, etc., goods which now mostly pass through the canal.

The boats frequenting the canal are what are called "chalands," some of them open and some of them decked, mostly constructed of iron, of a length of 125 to 130 feet, 15 to 24 feet breadth, and carrying from 300 to 450 tons, with 5 feet 10 inches draft of water. The iron chalands of the General Transportation Company which formerly came through the estuary of the Seine, have a length of 205 feet and a breadth of 26 feet, but they can not enter the general system of canals and are trading mostly with Rouen and Paris.

Then there are the Peniches or Pélandres, flat-bottomed boats of Flemish model, rectangular of form with rounded corners. Their tonnage varies from 250 to 700 tons on a length of 123 feet with a width of 16 feet, 7½ feet high in the middle, drawing 5 feet 10 inches; they can navigate such canals as have a depth of 6½ feet and locks of 125 feet length.

The towing is done by tugboats.

It is difficult to say what the cheapening of transportation by means of the construction of the canal amounts to, as the rates of freight are liable to variations, but one advantage of this new water way is a more regular and quicker mode of river navigation. As above said, grain, wine, timber, petroleum, etc., are largely forwarded by this canal, also cotton for the mills in the East, which formerly was exclusively shipped by rail; on the other hand, heavy and bulky goods, salt, building materials arrive in fair quantities. Another advantage is derived from the competition between the canal and the railroad, which latter had to reduce its tariff, amounting on some articles to as much as 1 franc to 2 francs and even 3 francs per ton.

The canal, passing through low lands, is not used for irrigation.

The following table gives the number of boats and tonnage up and down stream since the opening of the canal:

Total traffic for 1887, 1888, and 1889.

Year.	Upstream.		Downstream.		Total.		Number pinnaces.	
	Boats.	Tonnage.	Boats.	Tonnage.	Boats.	Tonnage.	Up.	Down.
1887.....	288	45,416	195	9,681	483	55,097	17	17
1888.....	1,161	224,960	1,140	66,545	2,332	291,574	182	199
1889.....	1,264	148,491	1,327	59,043	2,592	207,534	116	109

For the year 1887 the movement is from August 1 to end of December, and for 1889 from January 1 to August 31.

CANAL FROM CAEN TO THE SEA.

This canal has been constructed to give access to sea-going vessels to the port of Caen from Ouistreham on the sea, so as to remedy serious inconveniences which navigation through the river Orne was exposed to. It is constructed on a single level with locks at either end; its length is about 9½ of a mile (13,987 meters), with a depth of 17 feet.

The normal transverse section of the canal (as illustrated below) presents a bed (or cunette) with embankments, tow path, etc. This bed has at the bottom a width of 32 feet and at the top of 88 feet; the embankments are 16 feet wide, the tow-path 42 feet on the top and 72 at the base, with a height of 10 feet.

A dock (or gare) 700 feet in length is below the bridge at Blainville, and a second one of 975 feet in length is immediately above the lock at Ouistreham.

The canal is crossed by four turning bridges at important points, the abutments of which leave a passage varying from 40 to 40½ feet in width. The roadway of the bridges is 11½ feet wide, and their length is 85 feet. The construction of the canal was authorized by a law passed July 19, 1837, in which year the work was begun, but it was not until 1843 that the final project was adopted. The canal was opened to navigation on the 1st of July, 1857, though some necessary complementary work was not finished until 1859. At that time the canal had cost about \$1,940,000, including the locked basin at Ouistreham and the dock at Caen, called the New Dock; both these works costing about \$1,000,000.

The canal is fed by a sweet-water stream called the Odon, and by water drawn from the river Orne by means of a movable bar or dam, which obstruction is at all times, except in the winter season or spring tides, shut.

The canal is not used for irrigation, as the land through which it passes does not need it.

The following table for the year 1888 gives the imports and exports through the canal. The trade of the port of Ouistreham and of the old port of Caen through the river Orne is not included :

IMPORTS.

Merchandise.	Tons.	Merchandise.	Tons.
Coal	235,902	Oats	6,433
Timber	44,945	Ice	300
Oil seeds	6,842	Pyrites	590
Soap	1,963	Wheat	9,969
Cement	6,106	Oranges	390
Salt	2,161	Iron	100
Pig iron	1,938	Various*	7,004
Mineral tar	5,766	Total	331,219
Bricks	810		

* Various merchandise comprises coffee, sugar, hides, indigo, tallow, grease, etc.

EXPORTS.

Stone	1,680	Oil-cake	728
Paving stones	3,000	Various	1,685
Iron ore	5,514	Total	15,561
Barley	297		

F. F. DUFAIS,
Consul.

UNITED STATES CONSULATE,
Havre, France, October 3, 1889.

CANAL FROM NANTES TO BREST.

REPORT OF CONSUL SHACKELFORD.

The length of the canal from Nantes to Brest is 270 miles, divided into two sections, the first extending from Nantes to the city of Redon, a distance of 69 miles. It leaves Nantes by the Erdre, a small river emptying into the Loire. This stream, to use the French word, is *canalisée*, adapted for navigation by dams and locks. The dam and two locks are in the center of the city. The backwater from this dam renders the river navigable at all seasons of the year for canal boats and other small crafts. The canal follows the bed of the river for a distance of 15 miles; leaving the river, it continues on its course to Brest, passing by the city of Redon, forming junctions with numerous small rivers.

I am indebted to the chief engineer for the following answers to my questions:

1. Navigation was established between the rivers Loire and Vilaine by the completion of the canal, January 1, 1838.

2. The cost of the first section to the city of Redon was 7,752,531 francs 20 centimes. Of this section 24 miles was dug by hand and 45 miles by junctions with small rivers *canalisée*.

3. The width at the surface of the water is 13.48 metres, about 50 feet. Depth of water, 1.52 metres, about 5 feet.

4. The locks and their dimensions are as follows:

No. of locks.	Width.	Length.
	<i>Metres.</i>	<i>Metres.</i>
18	5.36	32.44
12	4.70	26.85
3	4.70	26.30
2	4.70	0.28

5. It was constructed by the Government and is the property of the state.

6. The boats belong to individuals.

7. The construction of the canal has increased the trade of the section of country through which it passes. The tonnage of goods transported by the canal was:

	Tons.
1838	21,580
1842	59,465
1876	96,231
1888	129,739

8. Boats loaded for the past three years:

Year.	No. of boats.	Tonnage.
1886	1,477	101,100
1887	1,773	119,549
1888	1,812	129,739

It is difficult to estimate the value of their cargoes, but the proportions of the articles transported may be classified as follows:

Articles.	1886.	1887.	1888.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Building stone	33	18	27
Wood for fuel and construction	27	30	36
Manure	13	24	10
Agricultural products	11	14	12
Miscellaneous	14	14	15

9. As to tolls, they were collected formerly by a fixed tariff of rates, but that system was abolished by law of February 19, 1880, and they are now collected by special agreements.

1. The water is supplied by rivers on the route of the canal and from the following sources:

Source.	Area.	Amount.
	<i>Hectares.</i>	<i>Cubic metres.</i>
Reservoir de Vioreau	181.65	7,451,280
Pond of Vioreau	29.95	594,108
Pond de la Probstiere	73.18	1,513,952
Reservoir de Boul de Birs	35.39	368,300
Reservoir d l'Etang au Mée	57.32	1,200,000
Total		11,037,640

CANAL VS. RAILWAY TRAFFIC.

In the reply to the eighth question it is shown that the articles transported by the canal are few in number and confined to heavy, bulky articles that pay low rates of freight; the miscellaneous paying freight falls to the share of the railway which I believe is the experience in our own country.

H. A. SHACKELFORD,
Consul.

CONSULATE OF THE UNITED STATES,
Nantes, France, September 12, 1889.

GERMANY.

GERMAN CANALS.

REPORT BY CONSUL EDWARDS, OF BERLIN.

A map issued by the Prussian minister for public works shows the German water ways and their capacity, viz:

1. Friederich Wilhelm or Muellerse Canal, which unites the Oder and Spree, is 24 kilometres in length.
2. Tinord Canal, which unites the Oder and Havel, is 48 kilometres in length.
3. Plauer Canal, which unites the Havel and Elbe, is 35 kilometres in length.
4. Ruppine Canal, which unites the Rhine and Havel, is 38 kilometres in length.
5. Bromlurger Canal, which unites the Oder and Weischel, is 28 kilometres in length.

IMPORTANCE.

These first canals have been and are still of the greatest importance to the Prussian Kingdom, and especially to the city of Berlin.

They connect nearly all the great rivers running through Prussia from south to north into the Baltic or North Sea.

The great progress made by Berlin during the past 20 years would have been quite impossible without these artificial water ways, as nearly all the building materials used in the extension of the city have been transported to Berlin through their agency.

The importance of Magdeburg as a center of the German sugar industry is likewise due to the facilities offered by these five canals for the cheap transportation of all sorts of bulky material.

OWNERSHIP.

All the canals in the Prussian Kingdom belong to the Government and are managed by the ministry of public works. They were constructed entirely for the benefit of the people, and have never been an object of speculation.

TRAFFIC.

The traffic is immense; the rates of transportation very low.

ADMINISTRATION.

The canals are administered with great care and with the best possible pecuniary advantage to the Government.

CONSTRUCTION.

The gradually falling courses of the rivers of Prussia favor the construction and operation of canals. Some canals were constructed exclusively for the purpose of preventing inundations, whilst some others serve only for wood floating.

By reference to Map II it will be observed that the Elbing-Nogat Canal leads to the "Frische-Haff," a part of the Baltic Sea.

7. The Johannsburg Canal unites several lakes, the principal traffic being wood floating.

8. Hamme-Oste Canal unites the Elbe and Weser.

9. Hunte-Ems Canal unites the Weser and Ems.

10. Jade Canal unites the North Sea and Ems.

11. Ems-Rhin Canal unites the Rhine and Ems.

12. Hadamar Canal unites the Elbe and Weser.

13. Eider Canal, near Kiel, leaps from the Baltic to the North Sea, is 48 kilometres in length, 11 feet deep, and 96 feet broad on the surface.

14. The Ludwig's Canal in Bavaria is very important, uniting the Donau, the Maia, and the Rhine. It is 188 kilometres in length, 5 to 6 feet in depth, 54 feet breadth on the surface, and 34 feet at the bottom.

15. Alsace-Lorraine-Rhine-Rhône Canal leads from the Rhine near Strasburg to the Rhône in France.

16. Rhine-Marne Canal leads from the Rhine near Strasburg to the Marne, in France.

17. Saar Canal leads from Saarburg to Saargemünd.

The testimony is unanimous that all these canals have been worked for the benefit of the people, and have aided materially in advancing the commercial prosperity of the country.

W. H. EDWARDS,
Consul-General.

UNITED STATES CONSULATE-GENERAL,
Berlin, October 9, 1889.

ALSACE-LORRAINE.

REPORT BY CONSUL JOHNSON, OF KIEL.

INTRODUCTION.

The canal system of Alsace-Lorraine consists of six main canals with several branch canals. The main canals are:

1. The Rhine-Rhône-Canal from the French frontier to Mülhausen and thence to Strasburg.

2. The Strasburg Canal system.

3. The Breush Canal from Goolsheim to Strasburg.

4. The Rhine Marne-Canal from the French frontier to Saaburg, Fabern, Pfalzbburg, Hochfelden, Brumath to Strasburg.

5. The Saar Coal Canal, from the Rhine-Marne Canal, near Gonder-singen, to Saarbrücken.

6. The Moselle Canal, from the Rhine-Marne Canal to Metz, with branches.

The number of boats frequenting the canals of Alsace-Lorraine is about 1,500, manned by about 4,000 persons. The size and carrying capacity of the canal boats are different, according to their purpose and according to the mode of building which is customary where they are constructed. There are six principal classes, which are shown in Table No. 1.

The Rhine-Marne and the Saar Coal Canal are regularly frequented by 1,195 boats, the nationality of which is shown here below :

Home country.	Number of boats.	Per cent.	Under 200 tons.	Over 200 tons.
Alsace-Lorraine	309	26	143	166
Prussia	219	19	138	81
Belgium and Luxemburg	83	7	0	83
France	567	47	23	544
Baden	17	1	14	3
Total	1,195	100	318	877

1. THE RHINE-RHÔNE CANAL.

This embraces the branch canals of Flünigen, Colmar, and New Breisach, also with the Strasburg Canal system and the Ill Rhine Canal.

The first project of a water communication between the Rhine, near Strasburg, Alsace, and the River Rhône near Lyons, France, by partly using the river Doubs and Saône, was made in 1744 by Marshal de la Cliche, but the execution was delayed until 1783. From that time, first of all, a communication between the river Saône, near St. Symphorien, and the river Doubs, near Dôle, was commenced, which was nearly finished in September, 1792.

The continuance of canalization was already granted when the Revolution broke out and caused an interruption in the course of construction. Not until 1805, under Napoleon I, could work be resumed upon the whole line from Dôle to Strasburg, but during the war time, notwithstanding the employment of prisoners of war the progress was very slow.

Although the canal was finished in its principal construction in 1814, the navigation upon it could only be opened to Besancon, France, in July, 1820, and up to Mülhausen in 1829.

The branch canal from Mülhausen to the Rhine near Flünigen, which can not be dispensed with as a water supply for the distance from Mülhausen to Strasburg, was commenced in 1824, but could only be opened in 1834.

According to the first project the expenses for the establishment of the Rhine-Rhône Canal in 1744 were estimated at 13,000,000 francs (\$2,476,190), but the execution of the work up to 1820 cost already 11,000,000 francs. For the further continuance there was deemed sufficient a sum of 10,000,000 francs, but even this sum, procured upon shares by a 6 per cent. loan, proved insufficient. The State had still to add for the total completion of the canal the sum of 7,000,000 francs, giving a real building sum of 28,000,000, and with further raised money 249,562, making a grand total of 28,249,562 francs, or 22,599,650 marks (\$5,380,870), which shows for a total length of 350 kilometres an expense of 64,570 marks (\$15,374) per kilometre.

Under the Emperor Napoleon I the canal was called "Canal Napoleon,"

under the Restoration "Canal Monsieur," and in 1830 it received again its original name, "Rhine-Rhône Canal," which is maintained up to the present time. After the accomplishment of the canal to Strasburg its prolongation into the Rhine was commenced at once. By the first project the river Ill, from the disembogement of the Rhine-Rhône Canal into it and up to its flowing into the Rhine, over a length of 23.8 kilometres, was to be made navigable for large size canal and Rhine boats. However, soon perceiving that the establishment of a connecting canal of only 2 kilometres length from the Ill near Ruprechtsan, below Strasburg, would be preferable in every respect, the Ill-Rhine Canal was executed as it is at present.

2. THE STRASBURG CANAL SYSTEM.

The canalization of the Ill within Strasburg, with its west branch, the so-called "Town-moat Canal," Stadtgrabers Canal, was begun in 1835 and concluded in 1840. The canalization of the Ill extra muros and of Ill-Rhine Canal was begun in 1838, and on the 1st of May, 1842, the whole distance from the Rhine-Rhône Canal up to the confluence in the Rhine could be opened for navigation.

The expenses amounted to:

	Marks.
For canalization of the Ill, and of the Town-moat Canal within Strasburg, over a length of 3,990 kilometres.....	608, 000
For canalization of the Ill above and below Strasburg, 930 metres long....	272, 000
For the establishment of the Ill-Rhine Canal, 2,293 metres.....	1, 120, 000
Total.....	2, 000, 000

The Colmar Branch Canal, a side canal of the Rhine-Rhône Canal, branches off from this near Arzenheim; it was built between 1860 and 1864, and has been in use since November, 1864. There were executed extraordinary repairs and new buildings from 1872 to 1877 inclusively:

1. Extended dredgings in the River Rhône, especially in the Flünigen Branch Canal.

2. Renovation of 99 pair canal sluice-lock gates.

3. Complete renovation of the brick walls on many sluices; on others, complete reestablishment in quarry stones, or combination of brick walls with quarry and square stones.

4. Repair of several very defective bridges, viz: (1) The bridge over the mill brook, with drawbridge across the canal near Zillisheim; (2) the bridge across the canal on the road from Riedisheim to Illzaeh; (3) the bridle-path bridge over the Ill near Illfurth; (4) Renovation of the superstructure of the drawbridge over the canal in New Breisach; (5) Renovation of the superstructure and of the skew-backs of the bridge over the canal near Markolsheim; (6) rebuilding in iron of the bridge over the canal near Eschan; (7) as also of the drawbridge over Sluice No. 85; (8) rebuilding of several small wooden bridges into massive constructions; and (9) rebuilding of the solid Eselsbrücke (ass's bridge) at the Fisher gate, near Strasburg, into a drawbridge.

5. A new sluice head below Sluice No. 85, near Strasburg, at the confluence of the Rhône Canal and Ill, enabling loaded boats to pass this sluice at low water.

6. A new warehouse in Flünigen.

7. A second new great port basin in Mülhausen, with the connecting canal from the northeast end of the basin to the Rhine-Rhône Canal, and two arched bridges leading over it.

8. The establishment of a bridge, built by the city of Mülhausen at

the south end of the basin in Newton street, which had been swept away by the Ill flood on October 5, 6, 1872.

9. The Breisach Branch Canal.

10. Twelve pair of sluice gates renewed; further, three defective sluices were rebuilt.

11. One lock bridge across the Ill within Strasburg, called "Tasanen-brücke;" (pheasant's bridge,) was put to a thorough repair.

12. A new warehouse near Sluice No. 85 of the Rhine-Rhône Canal.

13. New planting of trees on the Rhine-Rhône Canal and the Colmar Branch Canal.

14. A new wrought-iron railing on the port basin and 815 square metres of gutter and street plaster in Mülhausen and 550 square metres of slope plaster.

Besides this, considerable leakages were stopped, pavements effected, a number of sluice doors repaired, and a large draining sewer constructed along the Colmar Branch, Canal and up to the Rhine-Rhône Canal near Sluice No. 65 for the purpose of the removal of leaking water. For these structures extraordinary means were used, viz :

	Marks.
1872	143, 290
1873	509, 040
1874	101, 310
1875	58, 240
1876	221, 830
1877	87, 750

Total 1, 121, 460

For the ordinary maintenance of the Rhine-Rhône Canal were expended :

	Marks.
1872	238, 940
1873	158, 980
1874	164, 170
1875	142, 220
1876	224, 190
1877	175, 000

Total 1, 103, 500

This is in the average annually 9.33 mark per kilometre and for the whole canal in the average annually 183916 marks. In 1877 navigation had to be interrupted on account of extraordinary repairs from the French frontier to Mülhausen from 1st to 15th of February, and from 1st to 31st of August, together forty-six days; in the then Mülhausen district, on account of frost, twenty-nine days; in the then Breisach district, on account of the sinking of a boat, two days; in the then Strasburg district, on account of frost, from 22d to 31st of December, nine days; on account of high water, from February 15 to April 17, thirty days.

On account of want of water boats could only use the Fluningen Branch Canal with a draft of water of .80 metres during the time from October 1 until November, 1877. One boat was sunk on the canal; 11 corpses were found in the canal in 1877.

The old basin in Mülhausen, situated between the Sluices Nos. 39 and 40, near the railway depot, has a width of 60 metres and a length of only 265 metres; it has therefore in previous times been already insufficient for traffic. Besides this, it is too far distant from the great industrial establishments of Mülhausen and Dornach. For this reason the establishment of a second "New Port Basin" upon the so-called "Nord-

feld" (Northfield), on the northeast side of the city, was ordered by imperial decree, dated April 13, 1870, but the execution was prevented by the outbreak of the war.

By virtue of the treaty of the city of Mülhausen with the country administration, dated December 22, 1871, to the effect that the plans made by the French engineers should be executed and that the state should only pay a certain contribution, work was commenced in spring 1872.

This contract was revoked on the 3d of October, 1873, after the "administration of waterworks" had been organized on account of different difficulties. The administration of waterworks then undertook to carry out the work commenced.

By the first (French) project the river Ill was to flow through the basin, and Quatelbach (Quatel Creek) was to be fed partly by the Ill, partly by the Flüningen Branch Canal from the Rhine.

The Ill carries along with it masses of very fertile mud, which would have been deposited in the dead water of the basin, and so have been lost to the meadows of the Quatelbach. In consequence of the above facts, fifteen communities owning meadows on the Quatelbach and Vauban Canal made a protest on the 15th of July, 1872.

In order to avoid dredging and other disadvantageous operations, an entirely new project was made, by which the second basin is to form the prolongation of the projected city, enlargement in a straight line. The basin is 950 metres long and 40 metres wide, and the river Ill is led into the Quatelbach through a vaulted canal along the basin without being mixed with Rhine water. The basin is fed by Rhine water exclusively, and on both sides of it are made bridle paths of 5 metres width and store places of 12 metre width, as well as roadways of 8.5 metres width. A road bridge is built at the mouth of the canal, which is constructed to connect the basin with the Rhine-Rhône Canal. The sewerage serves for the emptying of the basin, the building expenses of which are estimated at 576,800 marks.

The Rhine-Rhône Canal is fed from the French frontier to Mülhausen by water from the river Harg, and from there principally by Rhine-water, the latter through the Flüningen Branch Canal. In consequence of the great leakage of the Rhine-Rhône Canal, which is built with coarse gravel, the want of water supply is so great that the Flüningen Branch Canal is unable to cover the loss of water, especially at low water in the Rhine.

This deficiency became more evident after the opening of the Colmar Branch Canal, in consequence of which the building of a new water-supplying canal was concluded by the French Government by decree dated August 12, 1863. This canal was called the Breisach Branch Canal, and was at the same time intended to furnish a certain quantity of water to the Ill for industrial and agricultural purposes.

This canal, now executed by the German Government, branches off from the Rhine 800 metres below the pontoon bridge near Alt-Breisach, crosses the landmark of Biesheim in a northwesterly direction and runs into the Biesheim Gieszen; follows this for 980 metres and reaches the Rhine-Rhône canal near Kuenheim, 700 metres above sluice No. 62, but does not flow into it until 50 metres below sluice No. 62, running so long close to the right hand side bridle-path. Up to this place it has a width of 10 metres at the bottom, a depth of water of 2 metres and connecting the Rhine with the Rhine-Rhône canal, it serves besides for supplying water also for navigation and rafting. Further on, in a similar way, running close to the right bridle-path, it follows the direction

of the Rhine-Rhône canal until below sluice No. 63 at the branching off of the Colmar branch canal; but this latter distance has only a width of 3 metres at the bottom and only serves for supplying water. Cross profile and water-descent are so meted that 9 cubic metres of water led off per second, of which 5 are intended for supplying the Rhine-Rhône canal and 4 for the Ill.

The part from the Biesheim Giessen (rivulet) to the Rhine-Rhône canal, 3,427 meters in length, and the ditch for supplying water, running along the latter with 3,237 meters length, have principally been made by the French Government from 1867 to 1870, but the completion, and especially the deepening of the bottom of the canal for 0.20 meters, as well as the costly condensation work, has been achieved by the German Government.

The distance from the Rhine to the Giessen, a length of 3,049 meters, was built in 1876 and 1877, and contains a large admission sluice with bridge close to the Rhine, an arched bridge in Grossmatten way and a bridge with massive skew-backs and iron superstructure across the Giessen (rivulet, slough) instead of the previous wooden one. The supply ditch from the Colmar canal to the Ill is 260 meters in length, built in 1877, branches off to the north side below the Ill sluice, is intended to supply the Ill with 4 cubic meters of water, and has a supply and a flood sluice, as well as a field bridge leading over it. All these structures have been opened for public use on the 1st of June, 1878.

According to previous experience a raft traffic from the Rhine through the Breisach Branch canal to the Rhine-Rhône canal may be expected; therefore a raft-port for rebinding of timber, suitable for the prescribed canal dimensions has been projected, with which there is to be connected an unloading place for two boats. In order to reach the Rhine-Rhône canal from the Rhine-Marne canal boats are obliged to use the Ill for a distance of 6 kilometers.

As the Ill has much descent within the city of Strasburg, a relay of up to eight horses has to be taken. Nevertheless often the difficulties of the passage up-stream are not overcome without causing interruptions in the boat traffic, especially injurious to the industry of Mülhausen. For the purpose of avoiding these disadvantages, previously a communication canal had been projected between Rhine-Marne and Rhine-Rhône canal, but in consideration of an amount of 826,000 mark for its execution it was abandoned. In order to overcome the aforesaid difficulties the introduction of towing with steam power has been taken in view. The total expenses amount to 80,000 mark. The expenses of management are covered by fees levied upon masters of boats.

3. THE BREUSCH CANAL.

A project of the canalization of the Breusch River was already taken in view at the beginning of the fifteenth century by Bishop Wilhelm von Diest, but was only executed 1682 by Marshal Vauban for the purpose of transmitting by this canal material for the construction of the citadel of Strasburg. For this reason the canal was managed and maintained by the military authorities until 1775, when it was ceded to the city of Strasburg as property under the condition of self-maintenance, which at that time amounted to 7,000 to 8,000 francs annually. In 1792, however, the military authorities again took charge of the management of the canal by reason of the neglect of the city of Strasburg to properly keep it up. Strasburg then had only to contribute an amount of 5,000 francs per annum.

In 1803 the management was taken charge of by the State. The city then had to cover the costs of maintenance alone. In 1824 the canal was made the complete property of the state, and the city was relieved forever from any and every contribution for maintenance.

Besides the ordinary maintenance, the following extraordinary repairs were made on the Breusch canal from 1872 to 1877 :

1. Eight pairs of sluice gates, and 8 sluice-bottom beddings renewed.
2. At 7 sluices the chamber slopes were new plastered, and many repairs of the brick walls of the gate chambers made.
3. Along the villages of Wolcheim and Oberschöffolcheim, 510 metres slope-plaster were made.
4. The skew-backs of the canal bridge near Oberschöffolcheim and their superstructure were raised and renewed.

The extraordinary repairs necessitated the close of the canal for traffic in 1873 for 51 days, and in 1877 for 78 days. In consequence of frost weather the canal could not be used at least 8 days, and at the most 41 days annually. Expenses for ordinary repairs were paid.

	Marks.
1872	11, 120
1873	12, 000
1874	14, 360
1875	10, 050
1876	16, 370
1877	9, 830
Total	73, 730

This is an average of 11,288 marks annually, and 621 marks per kilometre at a length of 19,730 kilometres.

For extraordinary repairs there were necessary :

	Marks.
1872	17, 960
1873	41, 020
1874 .....	.....
1875 .....	.....
1876	9, 940
1877	8, 000
Total	76, 920

The repairs in 1877 include the new plastering of the chamber slopes of the sluices Nos. 6 and 8.

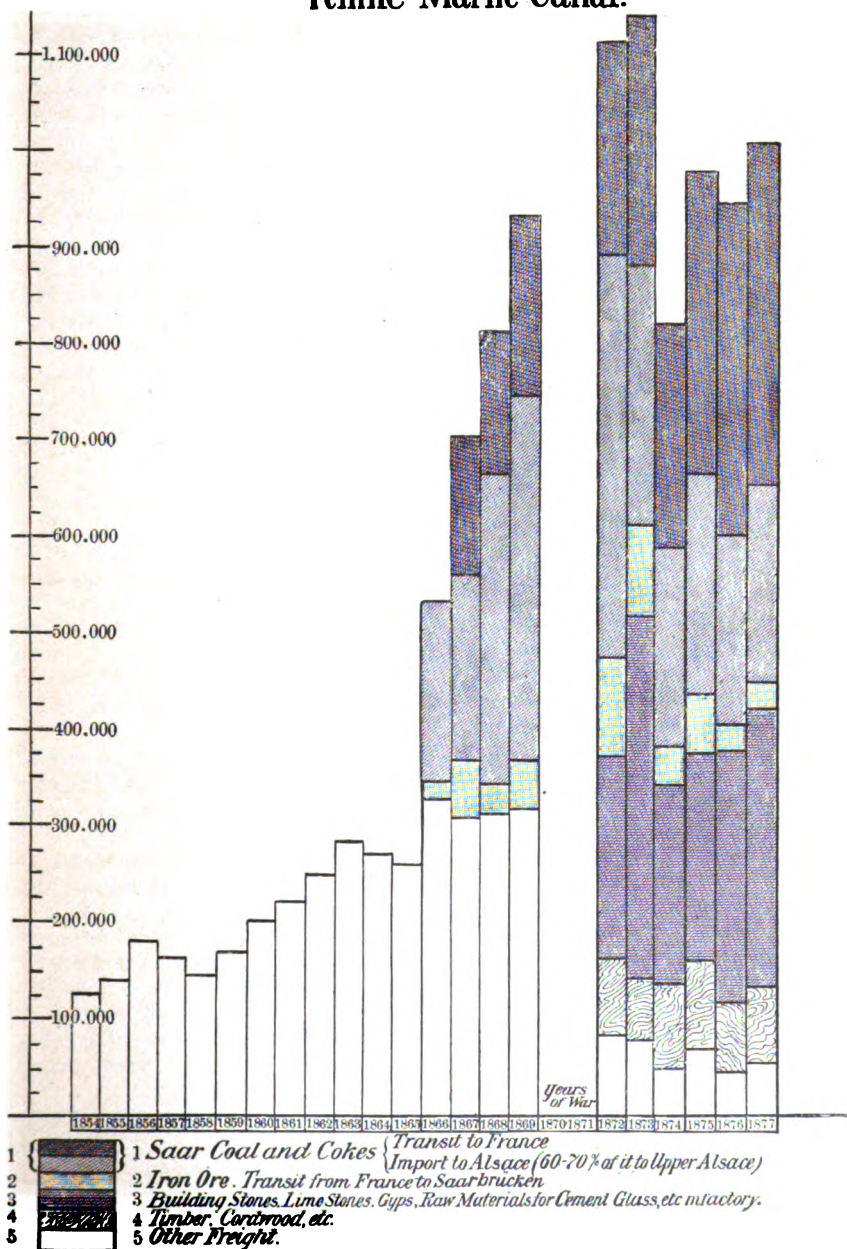
	Days.
For this purpose the traffic was interrupted from August 19 to September 5.....	17
On account of frost from December 23 to 31.....	8
On account of the repair of sluices from November 6 to 11.....	5
Together	30

THE RHINE-MARNE CANAL.

The technical preparatory works of this important canal were conducted by the engineer, M. Brisson, 1877, on behalf of an association for the purpose of effecting a connection of the Rhine with the Marne, and in an extended view with the river Seine, this is from Strasburgh to Paris and Havre. The work, commenced in 1838 and considerably progressed up to 1844, when the projected establishment of a railroad from Paris to Strasburgh for a time made the finishing of the enterprise doubtful.

The course of construction was, however, continued, and the canal was put in use in 1851 between Vitry and Nancy, and 1853 between Nancy and Strasburg.

Traffic upon the Rhine Marne Canal.



For the construction of the canals originally a "state credit" was given of only 36,000,000 marks, but as this proved insufficient it was raised to 60,000,000 marks in 1846, thus showing the building expenses for the disaster from Vitry (315 kilometres long) to be 190,476 marks per kilometre.

Extraordinary repairs and new constructions were executed from 1872 to 1887, as follows:

1. New construction of a culvert near Lagarde in order to be able to empty the holdings of the western descent independent of the French portion of this part of the canals.

2. Rebuilding in iron of the wooden crossway of the bridge near sluices No. 7 and 9 of the western, and No. 44 of the eastern descent.

3. New construction of a quay wall 108 metres in length for the customs service at Lagarde.

4. Construction of a store place for the continually growing traffic in timber and stone in the Lützelburg Valley.

5. New construction of a tool house near Lagarde and Hochfelden.

6. New construction of a tool storehouse with lodgings for canal guard near Hessen.

7. New erection of a sluice-keeper house at sluice No. 14 east.

8. Erection of wooden sluice-keeper's huts at the double sluice, Nos. 30 and 31 east, in Freibern, on the great tunnel near Arzweiler, at sluice No. 2 east, as well as on the supplying lake of Gondrexanges.

9. Purveyance of two pair new sluice gates.

10. New building of a tool-shop house with lodgings for bridge guard at the turn bridge near Vendenheim; and rebuilding of the wooden into an iron cross roadway from the bridge over sluice No. 22 east.

There were further supplied, a hand-dredging machine with two crafts and two skiffs, as well as a steam dredging machine with ten iron mud boats. For the ordinary management service eight new transport boats were built.

For the better management of the water supplying (feeding) service of the Rhine-Marne and the Saar Coal Canals there was established in 1876 a telegraphic connection on the one hand from the office of the "district hydraulic engineer" in Saarburg to the residences of the canal guard in Hessen, and of the guard at the supply (feeding) sluice in Nittingen on the other hand from the office at Saarburg to the residences of the canal guard in Gondrexange, of the guard on the lake of Rixingen, and sluice No. 1.

These telegraph lines have since 1878 been completed; new constructions were executed in 1877 as follows: 1. The canal guard house in Lützelburg; 2, a shop at sluice No. 2 east; 3, a bridge guard house at the turn bridge near Vendenheim; 4, a wooden bridge near sluice No. 21 across the canal was replaced by an iron bridge. Besides this there were 600 poplar trees on Vendenheim common ground replaced by fruit trees. For these buildings and purveyances were paid:

	Marks.
1872	6, 910
1873	34, 720
1874	19, 390
1875	26, 370
1876	49, 890
1877	12, 400

Total 149, 680

The ordinary maintenance caused the expense of:

	Marks.
1872	90,080
1873	100,230
1874	90,140
1875	76,270
1876	112,440
1877	78,680
Total	549,840

This is in the average annually 91,640 marks and 8.78 marks per kilometre.

After the transfer of the Saar Coal Canal to the district of Metz the distance from kilometre 0 of the Saar Coal Canal to kilometre 5 (mark-stone) in October, 1877, was put under the jurisdiction of the district hydraulic engineer in Saarburg. One canal guard station was abolished.

On the western descent of the canal shipping was suspended from January 6 to 31, 1877, as the French Government had ordered a blockade for that time.

On account of ice, shipping was interrupted on the canal in 1877 from March 2 to 6 and from December 21 to 31, together fourteen days.

Part blockings on account of the sinking of vessels and other accidents occurred at 6 places and interrupted the traffic on these localities for 17 days.

In consequence of the breach of a hanging bar the wire-rope bridge over the canal at Dettweiler fell down on the 14th of May; the same was reestablished within 28 days. In consequence of this accident projects were made for the establishment of fixed bridges instead of suspension bridges, the execution of which was intended.

The telegraph line opened on November 20, 1876, on the Rhine-Marne Canal, proved serviceable in 1877 for the prompt feeding (supplying with water) of the Rhine-Marne Canal and of the Saar Coal Canal.

Experiments made with the telephone in December, 1877, showed its practicability for the service along the canals. By introduction of the telephone two canal wardens may be dispensed with; at the same time accelerated movements of vessels between the different sluices will be effected.

5. THE SAAR COAL CANAL; IT IS THE BRANCH CANAL FROM MITTERS-HEIM TO DIEUZE.

The construction of the canal was commenced in 1862 and finished in May, 1866, since which time it was given over to public use. The importance of this canal is proved by the sudden rise of traffic on the Rhine-Marne and Rhine-Rhone canal, which was trebled in consequence of the conveyances from the Saar Coal Canal.

The building costs for the 75.6 kilometers long canal amounted to 13,326,819 marks, or 176,280 marks per kilometer.

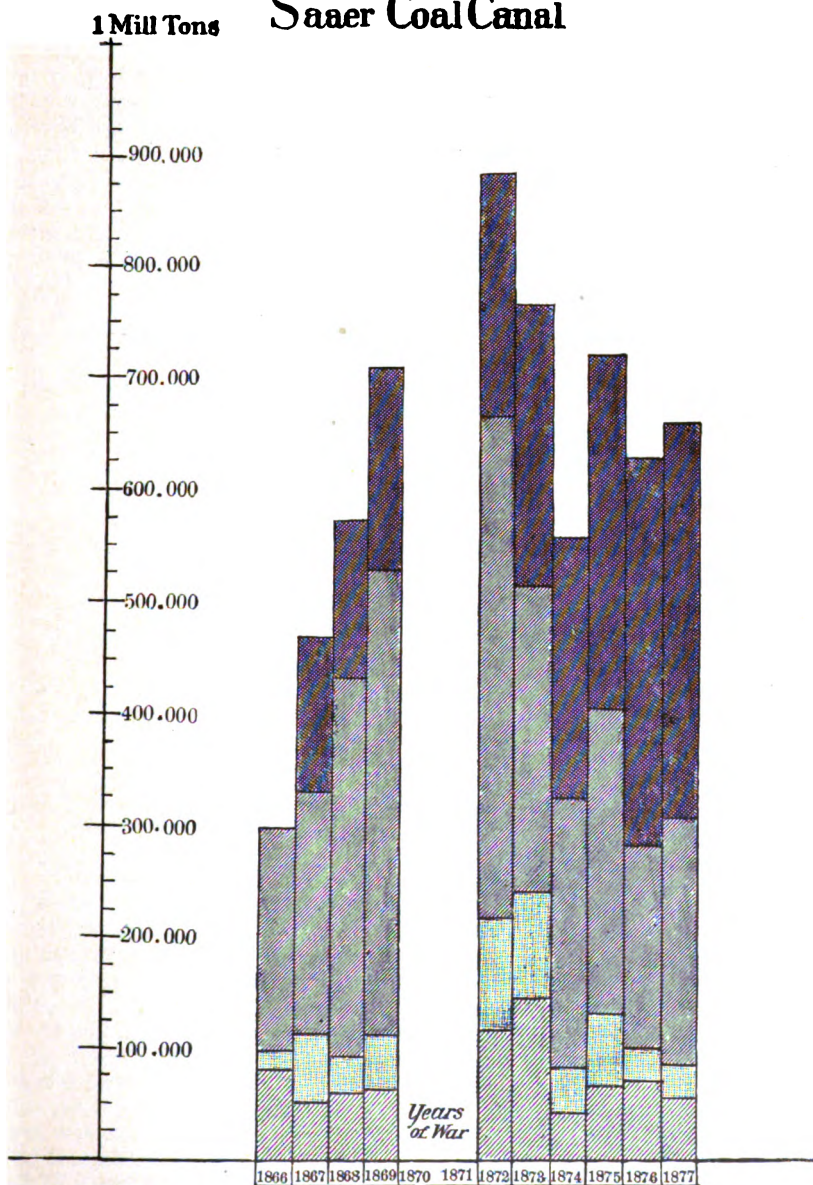
The following new buildings and special repairs were made on the Saar Coal Canal during the period from 1871 to 1877 inclusive, viz:

1. The construction of three bridges which had been destroyed during the war of 1870.

2. Rebuilding of a bridge for pedestrians which had been washed away by flood.

3. Twenty-eight sluice-master houses, the building of which had been commenced by the French Government, were finished and two new ones constructed.

Traffic upon the Saaer Coal Canal



- 1 { *Saaer Coal and Coke* (Transit to France)
- 2 { *Iron-Ore-Transit from France to Saarbrücken* (Import for Alsace-Lorraine)
- 3 { *Other Freight. Raw materials for the manufacture of*
Cement Glass and Stone-ware; Building
Stones Timber and Cordwood, Cement, Salt
Grain, etc., etc.

4. A decayed water defense work near sluice No. 28, at Saargemünd, was rebuilt.

5. For protection against underwashing the left bank of the canalized Saar was provided with a stone reinforcement for long distances, from Saargemünd up to the Prussian frontier, near Gündingen. As the Saar here forms the frontier between Lorraine and Prussia, the latter returns half of the expenses of this distance for repairs and maintenance.

6. The Saar Coal Canal, from the place of its branching off from the Rhine-Marne Canal, was planted with fruit trees up to Saargemünd.

7. The canal bed has been reinforced on many places, and brick walls were built in order to avoid offsliding from the canal slopes.

8. During the blocking of the canal, 1873 to 1876, considerable masses of mud were removed from the bottom, especially in the ports.

9. Considerable repairs were made at the iron aqueduct near Saaralben and on the iron sluice doors.

10. A new material and tool depot with canal guard lodgment was built on the great port at Saargemünd.

11. An iron path bridge was built at sluice No. 29, across the Wölferdinger Creek.

12. Considerable bank slides were removed near Saaralben.

For these structures were expended :

	Marks.
1872	105, 870
1873	72, 960
1874	19, 360
1875	11, 930
1876	23, 550
1877	14, 390
Total.....	248, 060

For the maintenance and management have been expended :

	Marks.
1872	88, 320
1873	106, 950
1874	88, 600
1875	56, 750
1876	105, 120
1877	65, 540
Total.....	511, 298

This is in the average 85,213 marks per annum, and in a length of 75,608 kilometres, 112.7 marks per kilometre. According to notations made at sluice No. 28, there were passing upstream, in 1877, 3,437 loaded and 8 empty boats, with together 11,745,516 cwts. of cargo; and according to notations at sluice No. 13, 3,487 loaded and 29 empty boats, with 11,652,593 cwts. cargo passed downstream. The greatest traffic was in the month of August as well up as downstream, with over 1,400,000 cwts.

The canal was not blocked in 1877. The only interruption which occurred was caused by the sinking of a large boat and lasted 2 days.

The branch canal to Dieuze.—Already, by decree of Napoleon I, dated April 15, 1806, the construction of a canal from the salt works near Dieuze to Saarbrücken had been ordered.

By this project the canal was to go from Dieuze through the valleys of the Verbach, Rhône, and Elbe to Saaralben, and thence through the Saar Valley to Saarbrücken.

Building was commenced, and the German prisoners of war nearly finished it, 1809 to 1814. The ensuing political events impeded the prog-

ress of canal building, which was not continued until 1866, after the Saar coal canal had been finished.

The work, which was going on well, was interrupted in 1870 by the war and was resumed by the German Government in 1872 and finished up to Lauterfingen; but the old Salt Work Canal to Dieuze has not been rebuilt, as there is no necessity for a canal for Dieuze and surrounding country besides the railway from Dieuze to Saaralben.

There were expended for these works:

	Marks.
1872	139,650
1873	106,760
1874	49,360
1875	54,440
1876	4,090
1877	1,670
Total	357,970

6. THE MOSELLE CANAL.

The reservoir lake of Gondreachange, 526 hectares, contains 6,520,000 cubic metres of water fit for supply flowing to it annually from its own hydrographic district; the reservoir lake at Rixingen, 130 hectares, contains 4,000,000 cubic metres of water, of which it receives 1,000,000 from its own district and 3,000,000 from floods in the two Saars; finally, the reservoir lake of Millersheim, 26.2 hectares, which contains 5,800,000 cubic metres of water.

But all this water is not sufficient in dry years, especially if the projected deepening to 2 metres depth of the Rhine-Marne and Saar Coal Canal should be executed. It has, therefore, been taken in view, by raising of its normal level of water for 1.5 metre, to increase the capacity of the lake of Gondreachange from 6,520,000 to 13,428,000 cubic metres annually as reserve (spare) water, which even in several succeeding dry years would be sufficient to guaranty a depth of water of 2 metres in the canals. The elevation of the closing dams and the other stowing works, as well as the acquisition of real estate, have been estimated at 1,011,000 marks. The cost of deepening the Rhine-Marne Canal to 2 metres water-depth is estimated at 522,000 marks, the Saar Coal Canal 172,000 marks, which would amount to a total of 1,705,000 marks.

The deepening also of the Rhine-Rhône Canal between Strasburg and Mielhausen is taken in view.

The traffic on the Rhine-Marne and Saar Coal canal, from the opening of each of them to 1877, is represented in a graphical way upon the affixed two tables, Nos. 3 and 4.

The partitions on the lower margin show the annual course; the vertical columns above them represent a comparative statement of the annually transported goods; the corresponding tonnage may be seen on the scale on the left-hand side. In order to show the importance of the canals for the transport, of the principal goods, the share of the coals, ores, building materials of minerals, as well as the participation in timber, in the total traffic, has been marked separately.

PROJECT FOR THE NIED CANAL.

Already during the French administration there was a canal proposed by the merchants of Lorraine, intended to connect the Moselle River, near Metz, with the Saar River, above Saarlouis. The technical preparatory work was commenced in 1872 in Lorraine, by the water-works

district engineer at Metz; in Prussia by the building inspector at Saarbrücken.

The direction of the canal was finally thus determined: Branching off from the port of the Moselle Canal at the Metz Railway station, crossing of the river Seille by bridge canal, then north of the railroad from Metz to Saarbrücken, passing Peltre and Jury, up to the water-shed between Seille and Nied, near Courcelles, through eighteen sluices of 2.60 metres descent each, in a total elevation of 46.8 metres.

At Courcelles commences the 40 kilometers long, vertical plane, and extends along the Nied Valley as far as Hargarten, touching Pange, Landonvillers, Bolchen, Ottendorf, and Teterchen. From Hargarten the canal descends with six sluices into the Bist Valley, along the places Falk and Merten, up to the Prussian frontier at Uberherrn. Besides the last-mentioned six sluices in Lorraine there will yet be ten more required on Prussian territory.

The already existing ponds, as those of Boulogny and Mutche, which can serve for supplying and for furnishing an extraordinary water supply, as well as the valleys near Beandre-court, St. Eprre, Oron and Morville, on the French Nied, and near Ham, on the Brist, acceptable for the establishment of reservoirs, have been submitted to a close technical examination.

For these projects was expended from 1873 to 1875 the total amount of 70,348 marks.

The expenses of the canal without pump works, over a length of 55 kilometres for Alsace-Lorraine, is estimated at a grand total of 17,040,000 marks; per kilometre, 304,286 mark; and by water supply with pump works at 20,500,000 marks. The execution of the project, however, is not expected to be carried out at present, owing to a railroad which is in course of construction from Peterchen to Buss (Saarbrücken) by the Government.

E. JOHNSON,
Consul.

UNITED STATES CONSULATE,
Kehl, September 21, 1889.

H. Ex. 45—10

Statement showing the principal measures and dimensions of the canals of Alsace-Lorraine, of the sluices, boats, etc.

No.	Main canals and branches.	Length. Kilometres.	Width. Metres.	Depth of water. Metres.	Sluices.		Boats.			Rafts.			Height of locks above water. Metres.
					Num- ber.	Least length. Metres.	Least width. Metres.	Great- est draft. Metres.	Great- est width. Metres.	Great- est cargo. Tons.	Great- est length. Metres.	Great- est width. Metres.	
1	Rhine-Rhône Canal (from the French frontier to Mulhausen Alsace) Branches (from Mulhausen, inclusive, No. 39 to Strasbourg): For the basin with connecting canal in Mulhausen..... Canal of Hünigen..... Canal of Colmar..... Canal of Brunsach, excluding feeding ditch..... Total.....	132, 000			40	30. 30	5. 20	1. 40	30. 00	5. 00	1. 15	29. 00	4. 80
		1, 000	15. 40	1. 60	47	38. 10	5. 30	1. 40	34. 50	5. 10	1. 15	30. 00	4. 80
		28, 200			4	38. 10	5. 30	1. 40	34. 50	5. 10	1. 15	30. 00	4. 80
		13, 340			1	38. 10	5. 20	1. 40	34. 50	5. 10	1. 15	30. 00	4. 80
		6, 478		2. 00	1	39. 00	7. 00	1. 80	37. 00	6. 80	1. 55	36. 5	6. 50
2	Strasbourg Canal system: Canalized Ill..... Touffort Canal..... Ill-Rhône Canal..... Total.....	181, 916											
		4, 920	30. 00	2. 00	2	39. 20	5. 30	1. 40	34. 50	5. 10	1. 14	33. 50	11. 50
		1, 870	30. 00	2. 00	1	39. 20	5. 30	1. 40	34. 50	5. 10	1. 14	33. 50	11. 50
		1, 847	27. 70	2. 16	2	55. 10	12. 40	1. 80	53. 00	11. 80	1. 55	52. 00	4. 80
		8, 737											(*)
3	Rhine-Marne Canal 4 Breusch canal..... 5 Saar Coal Canal..... 6 Moselle Canal..... Branch Canal.....	104, 360	14. 80	1. 60	64	38. 10	5. 20	1. 40	34. 50	5. 10	1. 15	33. 50	4. 80
		19, 780	11. 00	1. 30	11	53. 40	4. 50	1. 00	42. 00	14. 23	0. 95	32. 60	3. 80
		75, 408	15. 00	1. 80	30	39. 10	5. 20	1. 40	34. 50	5. 10	1. 15	33. 50	4. 80
		321, 635	13. 00	2. 00	5	38. 95	6. 00	1. 85	37. 50	5. 80	2. 15	36. 50	5. 60
		(1)			1			variable	35. 00	5. 80		33. 50	5. 60

* Unlimited, navigable for Rhine steamers.

† Such boats or rafts are sluiced three at a time.

; Such boats or rafts are sluiced two at a time.

§ Main canal, Moselle River.

Onaville to Novéant.

Novéant to Jony.

Jony to Metz.

† Navigable branch canals:

Ancy to Sluice Ars.

Sluice Ars to open Moselle.

Open Moselle:

Sluice La Polka to Wear Vaux.

Citadel Sluice to railroad depot.

Total.

The canals are blocked up by ice from three to six weeks annually.

21, 635

5, 635

1, 150

1, 935

435

2, 145

8, 950

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CANALIZED RIVERS IN THE DISTRICT OF FRANKFORT-ON-THE MAIN.

REPORT BY CONSUL-GENERAL MASON.

Of canals, strictly speaking, there are none of any consequence, either for purposes of irrigation or navigation, in the district of Frankfort-on-the-Main. Against the first of these necessities nature has provided a rainfall so copious and uniform that the problem of adequate drainage is often more important than that of irrigation.

In respect to canals constructed wholly for purposes of navigation, this region has remained hitherto unprovided, for the reason, apparently, that during the anteraulway period, when most canals in western Europe were built, the navigable Rhine and its important tributary, the Main, fulfilled, as was then thought, all the necessary requirements for water transportation. But the modern development of internal commerce, the steadily growing demand for cheap and largely augmented freighting facilities, have overrun, here as elsewhere, the capacity of natural channels of transport, and necessitated the improvement by canalization of two rivers in this district, viz, the Lahn from Giessen to its mouth near Coblenz, and the Main from Frankfort to its confluence with the Rhine at Mayence.

As a work of engineering the canalized Lahn has a certain technical interest, but its commercial importance is relatively limited. The canalized lower Main, on the other hand, although neither a difficult nor a costly work, is one of the most important improvements of its kind in Europe. The subject, moreover, has a special interest in this connection from the fact that the difficulties which have been here overcome are similar to those which obstruct so many American rivers; and the methods employed are readily applicable to a large proportion of the inland water-courses in our country wherein navigation is restricted or wholly suspended at certain seasons by rapids or insufficient water. Frankfort, although in early times the most important mercantile city of western Germany, began at a later period to lose some of this supremacy by reason of its comparative isolation from the Rhine, which, as the great commercial artery of this region, poured a constantly increasing trade into Mayence and Mannheim, its inferior but more fortunately situated rivals.

From Frankfort to Mayence, a distance of 20 English miles, the Main afforded, during all but very dry seasons or when frozen or swollen by floods, a practicable channel for small freight-boats towed by horses. But these boats were so inferior in size to the freight craft of the Rhine as to generally necessitate transshipment at Mayence, and this business of transfer contributed largely to the prosperity of that city. The obvious step for Frankfort was to either construct a canal to Mayence, or so improve the Main that the freight-boats of the Rhine could come readily to her wharves from Rotterdam, Cologne, Ruhrhaven, and other river ports without breaking cargo. These projects were long talked over, but nothing was done until after the annexation of Frankfort to Prussia in 1866. For various reasons the annexation gave a notable stimulus to the trade and manufacturing industries of this city. The one demanded cheaper outgoing and incoming freights, the other cheaper and more plentiful coals, lumber, iron, and other materials.

The chamber of commerce appealed to the Government at Berlin for aid in building the required canal, and in 1874, after the plan had been

approved by the state engineers, a preliminary appropriation of \$210,000 was granted.

But before the work had been seriously undertaken Mr. Ouno, a Government engineer, presented a new plan. Instead of cutting a canal from Frankfort to Mayence, he proposed to improve the channel of the Main and to circumvent its most shallow and difficult rapids by means of five movable wiers or dams, flanked by artificial channels and locks capable of passing the larger class of Rhine vessels. This scheme seemed so plausible that the canal project was dropped and the matter underwent another long delay. Finally, in 1883, all the adjacent states having agreed, the work was begun and was completed within 3 years.

The dedication and formal opening of the improved river took place on the 16th of October, 1886, and was fully described in a report submitted a few days later from this consulate. The canalization of the river was a Government work, planned and superintended by state engineers, and cost about \$1,309,500. The first dam and lock are situated about a mile below the city of Frankfort, the second at Höchst, an important manufacturing town on the right bank of the Main, the third at Okriftel, the fourth at Flörsheim, and the last at Köstheim, near the mouth of the river opposite Mayence. The locks are 285 feet long, 38 feet in width, with a lift of from 10 to 12 feet each, a minimum depth of 8½ feet, and the sluices are so well adjusted that the lock can be filled or emptied in from 4½ to 5 minutes. The dams are of wood and iron, so constructed that they can be laid down in time of floods or running ice, and raised into position again when the river resumes its normal condition.

The upper dam has increased by several feet the depth of water at the quays of Frankfort, which extend along either shore for a distance of 2 miles or more, but in order to provide for all contingencies it was necessary to construct a permanent harbor with sufficient capacity for winter commerce, and secure against floods and ice drifts. This work was undertaken by the city government, under the direction of Mr. W. H. Lindley, an accomplished English engineer, and cost, when complete, a little more than \$1,500,000. This harbor of refuge is an adequate and fitting complement to the work of the national government in improving the river. It is of ample depth, flanked by a massive dike of masonry extending on the interior side into a wide quay with railway connections, and pierced at its upper end by an opening provided with lock gates for convenient use in ordinary stages of water.

A spacious warehouse with sheds and railway tracks, and provided with elevators, hydraulic cranes, and all modern appliances for handling freight, are built along the landward side of the harbor, which offers moorings and anchorage for 50 or 60 Rhine boats of the largest class.

Thus constructed and equipped, this admirable work has been in use nearly 3 years, and we come now to the question of its practical utility as shown by achieved results.

What has the canalized Main done for Frankfort? Has it fulfilled expectations, and is it adequate to the purposes which prompted the undertaking?

The statistics of two complete years—1887 and 1888—are accessible, and from them may be somewhat roughly estimated the measure of its success. Frankfort is abundantly supplied with railroads, having among others an independent line on either bank of the Main from this city to Mayence, and in order to estimate the full benefit of the canalization improvement it is necessary to include both the rail and water freights in the account.

Omitting goods in transit and timber coming down the river as rafts the tonnage of freight sent and received during each of the last 3 years before the improvement of the river was as follows :

Year.	Quantity.		Percentage.	
	By water.	By rail.	By water.	By rail.
	<i>Tons.</i>	<i>Tons.</i>		
1884	110, 513. 7	864, 005	14. 8	85. 2
1885	150, 905	897, 040	14. 1	85. 9
1886	155, 956. 8	932, 090	14. 3	85. 7
Average per year	152, 425. 2	897, 712	14. 4	85. 6
1887	360, 062	1, 013, 628	26. 2	73. 8
1888	576, 798. 1	1, 231, 985	29. 6	70. 4

From which it appears that so far from suffering a loss of traffic by reason of improved water transportation, the railroads have gained steadily in business during the entire period. While the total transport by water increased 64 per cent. in 1887 and 42 per cent. in 1888 over the figures of 1886, the railway freight traffic gained 36 per cent. over the business of 1886 and 58 per cent. above that of 1887. Taking into account the rates actually paid upon this increased business, it is found that the economy of freights caused by the canalized river amounted to 1,141,502 marks in 1887 and 1,692,755 marks in 1888, and all upon an investment for river and harbor of less than \$3,000,000.

Nor is this all, nor even the most important part of it. The whole commercial and industrial life of the city has been quickened and restored by the new and improved conditions which the canalized river has entailed. The city has been put into fair and practical competition with its former rivals.

The cheapening of coal, coke, and raw metals has had a most important influence. Many kinds of manufacture which were previously impossible here, by reason of the high cost of fuel, are now prosperous and rapidly developing. Important iron mines farther up the valley at Bielen and Wertheim, which had long been abandoned since the charcoal supply failed, have now been reopened by the cheap coal of the Rhine Valley and the Moselle. Not only has the commerce of Frankfort been largely increased by this cheapening of freights, but it has been improved in both symmetry and character. The proportion of outgoing and incoming merchandise has been more nearly equalized, and the traffic of both rail and river thereby made more economical and profitable. Formerly Frankfort had nearly everything to buy and very little to sell. The freight was nearly all incoming, and both boats and railroad cars went back empty. Cheap fuel and materials have now developed local manufactures and given this community a larger export traffic, and the city, the railroads, and the river mutually profit by it.

Two years is, of course, too short a period to demonstrate fully the effect of this important work; but in so far as experience has yet gone the result has more than fulfilled the most sanguine expectations. The traffic of the canalized river has increased steadily from the day of its opening, and the one fault found with it now is that its locks are too short and its channel too shallow. The development of freighting facilities has taken here the same direction as in the United States, and notably on our western lakes and rivers; the size of vessels has been increased. When the Main River improvements were planned, it was thought that locks capable of passing boats 280 feet in length with 35

feet beam and 8 feet draft would be ample for all requirements of the future. But already this is seen to have been an underestimate, and plans are being earnestly discussed in the newspapers by which the locks of the Main may be lengthened and the channel still further deepened.

FRANK H. MASON,
Consul-General.

UNITED STATES CONSULATE GENERAL,
Frankfort-on-the-Main, September 6, 1889.

EAST PRUSSIA.

REPORT BY CONSULAR AGENT GADEKE, OF KÖNIGSBERG.

On looking at a map of Europe one may hardly find a country or a district which is so rich and abounding in water as eastern Prussia, and the established communications by this element have contributed not a little to the prosperity of commerce. However, it is to be regretted that as to the construction of canals the movement in it has been so very slack and leadenheeled that the commerce with the Russian neighbor has suffered more than could be anticipated with the continually increasing productiveness of Russia. The want of establishing commercial communications by water is a very old one in Prussia. About 500 years ago Winride von Kniprode, the renowned master of the German Order, made a journey from his castle at Marienburg to Angerburg by sailing vessel, thus making use of the communications existing between the Nogat and Vistula and the lakes of eastern Prussia. At the beginning of this century the floating of timber from the large Johannisburg forest by the Pissek, Narew, Bug, and Vistula to Danzig, had a great extent. Now this trade has gone asleep because of the nonregulation of the river near the Russian frontier, and the principal canal destined to unlock eastern Prussia proper between Angerburg and Allenburg, doubtless the most desirable of all Prussian canals, as it would not only bring in connection the Vistula and the Pregal and the large Masurian lakes and open a series of all sorts of industrial and commercial establishments, but also irrigate and meliorate many square miles of meadow ground and create a flourishing wood, etc., trade.

The canal for which the Prussian Parliament had granted the necessary sums 15 years ago has also gone asleep; the money was used for the amelioration of the harbor of Pillau. This canal was expected to have been constructed in 4 years; its length, 55 kilometres; the difference of the descent, the highest stand of the Mauersee and the lowest of the Allerver, amounted to 113.14 millimetres — 1,098 millimetres = 112,072 millimetres. There were planned six inclined planes. The breadth of the bottom of the canal was to be 10 millimetres, and the lowest depth 1 millimetre 40 centimetres, the canal to be practicable for vessels of 33.0 millimetres length, 4 millimetres 40 centimetres breadth, and 1 millimetre 1 centimetre depth. Its cost was to be about 10,000,000 marks. The dimensions were taken from those of the Oberländischer Canal which was built in 1860, also with five inclined planes, and which unites the Drausensee, near Elbing, with a lot of provincial seas down to Deutsch Eylau and Osterode. It is not very difficult to prove the prosperity of this canal by the ciphers hereafter; in 1861 the frequency of vessels amounted to 670 ships and rafts up and about as much down,

whereas the average of the last 10 years showed 1,187 vessels and rafts up and 1,792 down.

It must be remarked that some of the articles shipped are at present by far more frequent than on an average of the last 10 years.

On the whole, it is a grave and fatal error to confound the usefulness and prosperity of a canal with its rentability; at all events, the canal dues, if they can not be abolished altogether, must not be too heavy a charge for the trade and the most interested people, such as the neighboring land and forest proprietors, brickmen, manufacturers, and other industrials, shipper and workman, and all those people becoming more capable and getting more strength to contribute to the income of the state finances.

In 1733 Frederick the Great ordered in eastern Prussia a canal from the Skalist forest to the river Angerapp, where the wood could be conveyed by floating, but now the river is much impeded by stones and the interest for this trade is very little.

Other canals, which have been built from 1764 to 1767, are the Johannisburg Canal, the canals from Nikolaiken to the Taltersee, Taltersee to the Cottensee, Cottensee to the Schimannsee, Schimannsee to the Gürkelsee, the Löwentinsee to the Mauersee, Mauersee to the Moosensee, the canal near Darkehmen for the regulation of the Angerapp, the canal near Kiselkehmen for the same purpose, and the canal from the Beloonsee to the Niddensee.

All these canals together are about 16,800 feet long, are 48 to 52 feet wide, and 7 to 8 feet deep, but as long as there is no canal combining them with the Pregel River and Königsberg there will be not much use of them to be stated. In 1825 the Angerapp River was again regulated, 1845 to 1849 a new Johannisburg Canal was built, from 1850 to 1857 the Schimonker Canal, between Mauersee and Spirdingsee, but the chief commercial interest remained for the principal communications with Russia through the river Niemen and the adjoining smaller rivers Pregel, Deime, Nemonien, Gilge, Russ, Alle, and the Scharra, a river of 130 Russian versts long, combining the Oginsky Canal in Russia and the Dniejor with the Niemen.

I may mention here a canal which does not belong to this system, uniting the town of Memel with the river Minge, and which has a length of about 5 German miles, the König Wilhelm Canal. The traffic of this canal (built 1863 to 1873) in 1888 was 218 smacks, 2 prames, 4 steamers, and 22 steam tugs, and 1,648,641 cubic metres timber, *i. e.*, 13,759 score beams, round wood, and sleepers.

The canals which are the most important for the Königsberg trade are the Grosse Friedrichsgraben and the Sechenburger Canal. They form one canal, uniting at first the Gilge and the Deime, and by these rivers the Niemen and the Pregel. The Niemen, which gets the name "Memel" at the Prussian frontier at Schmallingken, brings the Russian supplies either in floats or in very flat vessels called "wittenmen," but the regulation of the Russian water ways is so much neglected that, for instance, in the above-mentioned Scharra, where the journey generally lasts 10 days, the rafts, etc., are often forced to remain 6 or 8 weeks in May and June for more water to allow them to proceed.

In the neighborhood of Tilsit the Niemen gets a third name, the "Russ," which divides into the Russ and the Gilge. This latter river interests us the most, for it brings all the merchandise to the Sechenburger Canal and then to the Grosse Friedrichsgraben, with the exception of a small part, which is forwarded either direct through the Gilge or the Nemonien, a river crossing the Sechenburger Canal, and being enlarged by the Timber Canal to the Curisches Haff, and from thence to

the Deime, near the city of Labiau, which river joins near Tapian the Pregel.

The greatest part of the flat vessels and all the rafts can not go to the Curisches Haff because of their flatness, and, therefore, the mentioned canals which join the Deime near Labiau are for the Königsberg trade of the utmost necessity. Both were built at the end of the last century, and the Sechenburg Canal, which at first had a breadth of 12 metres, has become a stately stream of 25 to 30 metres by the force of Gilge water, whereas the Grosse Friedrichsgraben, which has a more quiet water, has a breadth of 16 to 20 metres. During the last 10 years the Prussian Government has done much for the widening of this canal by buying many houses which peasants and fishermen had constructed on its banks, and digging out the land; always busy to keep a sufficient depth in all the canals by dredging and placing small wharfs where necessary. Often the arrivals are very large from Russia through the Grosse Friedrichsgraben and, therefore, some so-called Holzhäfen wood harbors are constructed in two or three places of the Grosse Friedrichsgraben.

The normal depth up to which the Government is held to keep the canals by dredging is only 1.20 metres, but it is now in work to enhance it to 2 metres. Larger harbors are also constructed at Schmalleninghen and at Tilsit.

In order to show the importance of the internal navigation, I give herewith the figures stating the traffic via Schmalleninghen, Labiau, and Königsberg in 1888.

VESSELS PASSING SCHMALLENINGHEN (RUSSIAN FRONTIER).

	Vessels up.			Vessels down.		
	No.	Size.	Cargo.	No.	Size.	Cargo.
Steamers	19	Tons. 2, 870	Tons. 865. 47	19	Tons 2, 870	Tons. 924. 21
Sailing vessels	62	120, 850	934. 21	1, 319	131, 602	80, 965. 43
Rafts				2, 666		*731, 980. 33

VESSELS PASSING LABIAU, CURISCHES HAFF.

Steamers	293	23, 481	18, 154	290	21, 054	17, 327
Sailing vessels	2, 206	213, 120	207, 441	221	207, 077	55, 969
Rafts	413		†165, 200	5		†1, 000

* Wood.

† Cubic metres wood.

In Königsberg: Passed internal vessels up, 4 steamers, 466 sailing vessels; down, 33 steamers, 480 sailing vessels; arrived up, 463 steamers, 5,011 sailing vessels, whereof 2,497 were fishing boats; down, 810 steamers, 2,764 fishing boats, of which 1,057 were potato smaks; rafts passed down, 14, with 7,512 tons, and arrived, 357, with 169,518 tons.

At present the chief interest of the Königsberg commerce is concentrated in the construction of the long-projected canal of 5½ meters depth through the Frische Haff, which is granted by the Prussian chamber of deputies, and which would allow steamers to take their full cargoes to Königsberg to discharge here, an enormous advantage, enabling Königsberg to compete more efficaciously with the Russian neighboring ports.

The depth of the Pregel at Königsberg is 6 metres and more, but in the Frische Haff, the large bay which receives the Pregel a few miles from Königsberg and leads near Pillau into the Baltic, there are now only

about 4 meters depth, so that the greatest part of the cargoes of all vessels is taken in lighters.

As for irrigating canals, the use and the benefit derived from them, we have no experience at all in eastern Prussia, as the building of sluices and the use of such is very rare in this country and exists more in the interest of industrials than of meadow owners.

CONRAD H. GADKE,
Consular Agent.

UNITED STATES CONSULAR AGENCY,
Königsberg, September 6, 1889.

WEST PRUSSIA.

REPORT BY CONSUL FAY, OF STETTIN.

The canals in the provinces of Posen and West Prussia are:

The Bromberg Canal, which bears its name from the town of Bromberg, connecting the river Brahe with the Warthe, and the main rivers, the Vistula with the Oder. This canal was constructed during the years 1772-'74 under the reign of Frederick the Great, and had the effect of bringing the produce of Poland to the markets of Berlin and other large towns. The length of this canal is 27 kilometres; width, 22 metres; depth $1\frac{1}{2}$ metres. The present traffic thereon is confined to lumber rafts and canal boats.

The Kraflohl Canal was constructed during the year 1495, and connects the town of Elbing with the Frische Haff (Fresh Bay). The present traffic on this canal is inconsiderable.

The Weichsel Canal was constructed in the fifteenth century, connecting the Fistula with the bay; the dimensions and traffic thereon are similar to the Bromberg Canal.

In the neighborhood of Stettin there are two canals, viz, the Königsfahrt (King's way) and the Kaiserfahrt (Emperor's way).

The former was constructed in the year 1841, leading from the Damansch to the river Oder; width 56.5 metres, depth 5 metres.

The latter, leading from the bay to the river Swine, was completed and opened in the year 1880. Length, 9.3 kilometres; width, 60 metres; depth, 6 to 8 metres.

The construction of these two canals, together with the dredging of the river Oder, has greatly improved the shipping facilities of this port.

The effect has not been to reduce the cost of transportation, but it has shortened the requisite time from the outport to Stettin, and facilitates the passage of larger vessels to this port.

These canals were constructed by and are under the control of the state. No charges are levied thereon.

The record shows a greatly increased traffic since the construction of these ducts; for example, ships arriving in Stettin during the year 1840, 1,588 with 171,240 regular tons; during the year 1844, 3,977 with 1,274,124 regular tons.

Irrigation is not necessary in this part of Germany.

ANDREW F. FAY,
Consul.

UNITED STATES CONSULATE,
Stettin, September 3, 1889.

GREECE.

THE CORINTH CANAL.

[From the London Morning Post, October, 1889, transmitted by Consul Williams, of Rouen.]

Owing to various causes, one of which was the additional outlay involved in altering the slope of the canal cutting, and another the late financial crisis in Paris, French capital being largely interested in the scheme, the work of construction on the Corinth ship canal was recently somewhat delayed, the consequence of which was that the canal could not be completed at contract time, the end of 1888. This caused some reaction, but those were wrong who predicted that the undertaking was therefore doomed. So far from this being the case, it is well recognized that the canal is of far too much importance for the shipping trade of the Mediterranean to be thus easily abandoned. As a matter of fact, at present all vessels trading between the Mediterranean ports of France, Spain, Italy, and Austria, and the ports of Greece, Turkey, Asia Minor, the Black Sea, and the Lower Danube, are obliged to round Cape Matapan, thus going out of their course first 2 degrees south and then 2 degrees north again. By making the canal through the isthmus of Corinth, the route for goods from Adriatic ports will be reduced 185 nautical miles, and from the Mediterranean by 95 miles. The canal intersects the isthmus of Corinth in a straight line at its narrowest part, its total length being just under 4 miles, and follows exactly the line of Nero's project, joining the Gulf of Corinth with the Gulf of Athens. It will reach deep water at both ends about 220 to 330 yards from the shore. The bottom width of the canal (72 feet) and its depth (26½ feet) are the same as those of the Suez Canal; but the proposed slope of 1 in 10 through the rocky portion of the cutting will afford a width at the surface of the water of only 77½ feet, and a cross section of 2,032 square feet, instead of the surface width of 177 feet, and the cross section of 3,272 square feet of the Suez Canal. This small section of the Corinth Canal will be somewhat disadvantageous for navigation, but its depth and width at bottom will enable the largest ships to pass. At the same time the fact that the canal is perfectly straight, and that the navigator can thus see from one end to the other, will greatly facilitate the passage of vessels, while the current will be but small, the difference of the tide between Isthmia (the new town founded at the eastern end of the canal) and Posidonia (at the western end) being only 4 inches. In order to disturb the surface of the water as little as possible during the passage of vessels, it is proposed to employ stationary rope haulage. By this method of transport also vessels will be kept fairly in the middle of the canal, and its sides will be little liable to damage. The sides of the canal, from the bottom to 6½ feet above the surface of the water, will be lined with concrete blocks. The approach channels, or harbors, at each end of the canal, are to have a bottom width of 328 feet, and will be protected by rubblestone jetties.

In the original design, as we learn from a paper by M. Armand St. Yves in the "Annales des Ponts et Chaussées," the total excavation was estimated at 12,865,000 cubic yards, including about 2,400,000 cubic yards for silts or eventual enlargements. The nature of the strata had, however, not been sufficiently investigated, the region being volcanic. When the cuttings had reached some depth a large number of faults were encountered, and a considerable disturbance of the layers of deposit of the tertiary strata was revealed. The maximum depth of cutting to the bottom of the canal is 284½ feet, and the mean depth for a length of 2.6 miles 190 feet. With this mean depth the amount of actual excavation will probably not exceed one and one-half times the quantity originally estimated. The work of excavation was commenced in April, 1882, and by the close of 1884 two converging jetties 1,310 feet and 1,640 feet long, respectively, with an entrance between their extremities 265 feet in width, had been constructed for the harbor in the Gulf of Corinth and one jetty on the northern side for the harbor in the Gulf of Athens, this being sufficient. But the excavations for the canal itself effected up to the end of 1884 amounted to only 1,700,000 cubic yards, and it was at once seen that at this rate of progress the canal could not be finished by 1888, as stipulated in the concession. M. Bazaine was then appointed chief engineer, and work was pushed forward more rapidly, so that by the close of 1887 the total excavation accomplished amounted to 7,978,000 cubic yards. During the operations of the 3 years, 1885 to 1887, it was found, however, that further works would be required, and in December, 1886, M. Bazaine reported that it was necessary to protect the sides of the canal with masonry in hydraulic lime or cement mortar for a height of 33 feet along a length of from 2½ to 2¾ miles to preserve them from erosion, to form a bench not less than 5 feet wide on each side of the canal 6½ feet above sea level, to enable the walling to be carried out, and to ease the slopes at certain parts of the cutting to insure their stability. The engineer estimated that this necessitated

2,355,000 cubic yards of additional excavation and an increase in cost of £400,000, and that this would extend the time of completion to the close of 1890. The extension of time asked for was granted, and the Greek Chamber voted £600,000 for the additional outlay and the supplementary works proposed. As the canal is crossed by the Corinth and Athens Railway, a bridge had to be constructed before the work of excavation was begun. The bridge, an iron framework structure of a span of 262 feet, is 164 feet above the level of the canal, and has, besides the railway track, a roadway for vehicular and passenger traffic.

Up to June last £1,480,000 had been expended on the canal works, and the number of workmen at present employed varies between 700 and 1,100. The workmen include Armenians (navvies), Italians (miners), Montenegrins, and Greeks. The rolling-stock employed consists of 12 locomotives and 710 trucks, and there is a railway track 23 miles in length. The total expenditure for the canal works is estimated at £2,400,000, or about £638,000 per mile. This is very high, compared with the Suez Canal, which cost about £20,550,000 for a length of 92 miles, exclusive of the portion through the Bitter Lakes, or £223,000 per mile. But, of course, in the case of the Suez Canal, the excavations were chiefly in sand and other light soils, while for the Corinth Canal the work is through rock formations. From the outlay involved an idea may be formed as to how the Corinth undertaking will pay. It is assumed that about 300 vessels from Trieste and Fiume, and as many from Italian ports, will pass through the canal annually, while it is calculated that 730 Greek ships will use the canal. This would give a total of 1,230 vessels annually, of an average tonnage of 1,500 each. As it is proposed to levy a toll of 1 franc per ton on vessels coming from the Adriatic, and one-half franc on all other vessels, besides 1 franc for every passenger, this is estimated to yield an annual revenue of 1,500,000 francs (£60,000). This would give at first only about 2½ per cent. on the capital outlay, and from this would have to be further deducted the expenses for collecting tolls and keeping the canal in repair, although the latter item can not be very heavy, considering the substantial nature of the construction. It remains to be seen whether the revenue will go on increasing, as the value of the canal to shipping is realized. At present no one can say whether the heavy expenditure was justified.

RUSSIA.

REPORT BY CONSUL-GENERAL CRAWFORD, OF ST. PETERSBURG.

THE BASIN OF THE VOLGA.

The Volga, as a navigable river, reaches 2,233 miles. Running first from the west to the east, rising somewhat to the north towards Rybinsk, where it suddenly turns to the south, it thus divides the most wealthy provinces of Russia into two parts, the eastern and western, thus forming a common line of communication from the northwest to the southeast. On its banks are situated thirty-six towns, twenty-seven wharves, and numerous large and small villages, where all kinds of industry are carried on. The tributaries of this great river are, the Kamy, Oky, Soury, Onjy, Kostromy, Shakesny, and the Mology. With the aid of these rivers the Volga connects very remote districts and grasps very important industries. From the fertile valley of Central Russia to the still uncultivated but rich lands extending between the upper flow of the river Obi and the southern forks of the Oural chain, from the virgin forests of Siberia to the shores of the Kamy and the Don, this grand stream stretches out her arms for the wealth of the country and thus becomes the recognized benefactress of Russia.

The historical development of the Russian Empire clearly shows the great commercial importance that lies in the flow of the Volga itself. The prosperity of Moscow has been perceptible only since the provinces, formerly called principalities, of the Volga, viz. Galitskoy and Nijgorodsky, were annexed to it; while the grandeur of Russia dates from the subjugation of Kazan and Astrakhan—in other words, from the

time when the Volga became a thoroughly Russian River from its source to the Caspian Sea.

The basin of the Volga embraces 21 provinces, occupying a territory of 1,333,333 square miles, with 35,000,000 of inhabitants. According to official figures this basin contains more than 7,000 factories, nearly 10,000,000 horses, as many horned cattle, and more than 30,000,000 of sheep, with great numbers of other domestic animals.

The average yield of cereals obtained from this basin amounts to nearly 1,250,000,000 bushels, and of this product not more than 800,000,000 bushels are consumed at home; the remaining 450,000,000 bushels being largely used in the manufacture of beer and whisky, together with immense quantities of dairy products, great numbers of horses, cattle, and sheep, the wealth of the forests, together with the metallurgical manufactures, which alone amount to more than 1,080,000,000 pounds per annum, with the products of the salt lakes lying in reach of the Volga, and finally with the output of the 7,000 factories above mentioned, with great quantities of koustar manufactures, seek transportation.

Moreover, the Volga still represents the principal means of communication and transport into Russia from the Caucasus and Persia. On this river are transported great quantities of merchandise from the center of Asia and from Khans; also articles of Chinese manufacture are floated down the Volga. Thus this river defines itself as the general line of traffic, uniting different tribes and peoples settled in Russia, a natural indication of its national importance.

Notwithstanding these facts the bulk of the products of the vast Volga Basin is unable to find an exit. This elevated basin, situated in the interior of Russia from the very source of the Dneiper and the Dvina to the central flow of the Don and to the limits of southern Siberia and even to the Himalaya Mountains, thus including an important portion of Europe and nearly all of central Asia, by its geographical situation is practically isolated. In all this vast country there are no natural waterways to unite the points of interior markets. The Volga flowing into the Caspian, an inland sea; the barren lands surrounding its mouth; the occupations of the nomads raiding in these sands, render it possible to dispose of all this vast product in one direction only—to the north.

Navigation on the North Sea is always difficult and is impracticable during a considerable portion of the year; whereas to the northwest, from the Volga to the nearest point of the Baltic, there lie 300 miles of lowland, thick set with little lakes and marshes, thus rendering such an outlet inaccessible for all kinds of heavy freight. For these reasons an enormous product, representing the labor of nearly the half of all Russia, as well as those goods transported from the neighboring eastern countries, can come to the Volga only to be freighted upstream, with no favorable opportunity of reaching the interior national exchange.

CANAL TO UNITE THE VOLGA AND THE BALTIC SEA.

From these facts it could hardly be otherwise than that Russian manufactures should suffer. Therefore the wisdom of constructing artificial water ways to furnish a means of disposing of the freight floated on the Volga, viz, the products of a large portion of Europe and of the western part of Eastern Asia, must be apparent. A practical solution of this question, it is argued, lies in the building of a canal from the Volga to the Baltic Sea.

The experience of Russia for more than 60 years, together with

researches undertaken during the past 150 years, has proved conclusively that the best plan that can be adopted for the building of such a canal is that known as the Mariinsky system. It is therefore evident that the reconstruction of this system should be made on such a plan as would render all traffic on the Volga and on the new canal profitable not only for the present, but also for the future. In fact, it is argued by the ministry of ways and communications that the plan adopted should be such as would construct an artificial water way equal to the Volga itself for purposes of navigation; that boats floating on the Volga should be able to float with facility on the entire Mariinsky system, no matter how heavily freighted; and, in brief, that it should fulfill all the requirements of traffic from the entire Volga basin.

During the reign of the Rweigs it was impossible to unite the Volga with the Baltic, inasmuch as the shores of this sea did not belong to Russia. Therefore the direction of commerce was of necessity toward the north, thereby establishing the temporary commercial importance of Arkangel. But even at that period the inconvenience of traffic through the White Sea and the Northern Ocean was recognized; and this knowledge caused John of Grozna to make war in Livonia, ending, it is to be regretted, unhappily. When Peter the Great, thanks to his war against the Swedes, set a firm foot on the coast of the Baltic Sea, one of his first thoughts was to fortify this acquisition that it might become the first link to unite Russia with the West. The next step of this mighty genius was the almost miraculous building of Petersburg; but to fortify this creation of his it became necessary to guaranty to the inhabitants an ample supply of provisions. The sterility of the surrounding country, which at that time was made to be inhabited by imperial force, able not only to annul such a guaranty, but absolutely to refuse to supply the principal articles of food.

The provinces of Petersburg, Novgorod, Pskoff, Tver, and Olenetz even to this day can not supply their own wants and are obliged to call upon their neighboring provinces for bread. At that time the thought of exporting cereals from these provinces never occurred to anyone. Economic conditions of such importance naturally called for political and strategic measures. It was necessary to support and strengthen the newly fortified capital and give it that administrative power which, according to the logic of things, the capital of such a nation demands. Such requirements finally led to the question of uniting the Volga with the Baltic Sea, apart from all conditions of State necessities, increasing with the rapid growth of the city, which has now become the capital of Russia and the political center of this great Empire.

Beginning with Peter the Great, who by the strength of his sound brain recognized the immediate importance of such a construction, the old Marie Canal system made but imperfect progress until in later years, when, burdened with accumulating obstacles of many sorts, including serious climatic difficulties, Petesburg was brought nearly to a state of famine. In view of such a possibility the Government, public opinion, and commercial advice urged the necessity of building a canal from the Volga to the Baltic, thus encouraging the manufacturing interests. At that time, however, neither governmental nor commercial opinion could form an approximate idea of the dimensions necessary for such a waterway if it would supply the future demands of the Russian capital of to-day.

In 1723 Peter the Great acknowledged the desirability of improving the Vishnivoltza Canal system, which, on account of its location, is unable to accomplish what is desired, the traffic thereon being depend-

ent upon the quantity of water accumulated in the reservoirs, and return traffic being impossible.

Later, in 1764, it was thought possible to obtain a satisfactory connection of the Volga with the Baltic by constructing in addition to the Viushnivolotz Canal the Tickvinsky, although shallowness of the river threw much doubt upon the practicability of the project, especially if such a connection were intended to do anything more than assist the general traffic and handle the local freight.

Finally, when necessity demanded the building of the Mariusky system, the demands of Petersburg and of foreign exports in no way equaled those of to-day. Through the sluice-way locks, built with chambers of 15 fathoms, it was with difficulty that 800 vessels could pass during the navigable season, carrying freight not exceeding 192,857 tons, scarcely more than a trifle when compared with the demands of Petersburg at the present time. In fact, at that day no inventive genius could have attained the results desired and possible now; no imagination could have foretold then that the discovery of steam would render futile all other modes of river navigation, nor have foreseen its effects on all branches of manufacture. And, moreover, at that time it was not possible for the Government, because lacking in both money and credit, to construct such a canal system as would be sufficient for the present demands. Even as late as 1810 the entire income of the Imperial Treasury was only 125,000,000 assignats, a sum representing only 41,667,000 metallic rubles, or about \$20,000,000.

When the Marie Canal system was constructed Petersburg numbered but 300,000 souls and her exports amounted to about 3,000,000 tons, whereas to-day the city has nearly 1,000,000 inhabitants and exports more than 12,000,000 tons.

THE MARIE SYSTEM.

On this water way, beginning from the middle of May to the 1st of July, depending upon the caravans, from 30 to 35 vessels are dispatched daily from Rybinsk. If the sluices and other complications of the system allowed this number to pass through from Rybinsk without delay, they would arrive at St. Petersburg in 30 to 45 days; but as the sluices at Rybinsk pass on an average from 25 to 30 vessels a day, therefore every day increase, the blockade at Rybinsk. Moreover, with the beginning of the second half of July the rapidity of transportation generally slackens, because of the dark nights and prevailing winds. Taking these facts as a basis the calculation as to the rate of the Rybinsk caravan is as follows:

By dispatching in the month of May 300 vessels from Rybinsk, they will reach St. Petersburg in 30 to 35 days. By dispatching the second 300 vessels it is necessary to add 5 days, and they will reach the same destination in 35 to 40 days. The third 300 vessels require an additional 5 days and they will be 40 to 45 days on the road; thus the first 1,000 vessels or 241,071 tons of freight will be from 30 to 45 days on the way from Rybinsk to St. Petersburg. When the second 1,000 vessels are dispatched it is necessary to add not 5 days, but 7 days of delay for every 300 vessels, and the journey of these 1,000 vessels will occupy, the first 300 vessels from 47 to 52 days; the second 300 vessels from 54 to 59, and the third 300 vessels from 61 to 66 days; so that the second 1,000 vessels or 241,071 tons of freight require 47 to 66 days for their journey. When the third 1,000 vessels are dispatched it is necessary to add 10 days delay to every 300 vessels started; thus the first 300 vessels of this 1,000 will be from 71 to 76 days on the road, the sec-

and 300 vessels from 81 to 86 days, and the third 300 vessels from 91 to 96 days, this 1,000 requiring from 71 to 96 days for its passage.

Having approximately calculated the result, it is found that 610,714 tons of goods, the yearly average transport of freight by the Marie Canal system, require on an average from 62 to 67 days' journey from Rybinsk to St. Petersburg, in which are included 30 days' journey and 32 to 37 days for necessary delay; the average rapidity of the transit is from 10 to 12 miles a day.

The price of transport on the Marie Canal system from the inauguration of the Rybinsk-Bologæ Railway varies from 10 to 12 copecks per pood, or 36 English pounds, whereas 10 copecks (5 cents) is the real cost of transit; thus leaving a ridiculously low profit for the shipper, even under the most favorable conditions.

To the average of 11 copecks the following expense must be added: Say 1 copeck for the sacks or bags for cereals; $1\frac{1}{2}$ copecks the average cost for insurance during the journey; duty, one-half copeck; storage at Rybinsk, freighting, and discharging at St. Petersburg, $1\frac{1}{2}$ copecks per pood, so that the total cost for the transport of goods from Rybinsk to St. Petersburg by the Marie Canal system, including the expenses at Rybinsk, amounts to $15\frac{1}{2}$ copecks per pood, or evaluating the goods averaging one with the other at 1 rouble, or 50 cents in United States currency, the cost per pood or 36 English pounds will be $15\frac{1}{2}$ per cent., or for the 610,714 tons the considerable sum of \$3,000,000.

Both the Government and the people have always regarded the Marie canal system as the most important water system of the Empire, uniting as it does the basin of the Volga with the port of St. Petersburg; but the real value of this canal can be appreciated only when one becomes acquainted with the immense increase of freight brought to the Volga at the Rybinsk wharfs. The following statistical table will show the amount of merchandise that was transported to and from Rybinsk during the years 1855-1882:

Years.	Freighted at Rybinsk.				Freighted through Rybinsk.			Total freight.	Total value.
	Ves- sels.	Aver- age freight.	Freight.	Value.	Ves- sels.	Freight.	Value.		
	No.	Tons.	Tons.		No.	Tons.		Tons.	
1855	3,264	236	771,573	\$7,743,500	2,188	68,721	\$3,603,000	840,294	\$11,346,500
1857	3,694	225	913,323	15,837,500	2,767	88,939	5,844,000	1,002,262	21,701,500
1860	2,321	217	503,678	12,990,500	1,790	57,357	3,000,500	561,035	15,991,000
1863	2,864	283	811,393	15,847,500	338	43,457	1,554,500	854,790	17,402,080
1864	2,854	269	768,664	12,283,500	315	40,500	1,449,500	809,164	13,733,000
1865	2,406	278	659,009	18,070,500	835	40,532	1,442,500	699,541	14,493,000
1866	2,832	308	871,877	19,090,500	412	51,927	1,500,000	923,304	20,590,500
A.v. transport.	2,890	260	756,907	13,840,500	2,248	71,727	4,149,000	868,009	17,989,500
1867	2,660	342	910,469	18,610,500	351	47,693	1,696,000	958,062	20,306,500
1868	2,768	315	871,714	19,526,000	432	55,671	1,991,500	930,600	21,517,500
1869	3,254	374	1,220,110	22,959,000	448	57,118	2,037,500	1,277,229	24,996,500
1872	3,254	374	998,485	21,389,000	443	57,118	2,037,500	1,277,229	24,996,500
1873	2,618	385	1,006,602	21,780,500	443	57,118	2,037,500	1,277,229	24,996,500
1874	2,637	376	986,223	21,292,000	1,392	121,098	3,527,000	1,099,546	24,819,000
1875	2,550	495	1,262,234	23,154,500	1,279	121,564	2,978,500	1,390,130	26,133,000
A.v. transport.	2,780	379	1,036,912	21,244,500	1,335	121,339	3,252,500	1,158,698	24,497,000
1876	3,409	408	1,427,660	24,859,500	1,020	95,014	2,674,000	1,522,591	27,534,000
1877	2,868	429	1,249,007	23,305,500	902	81,369	2,268,500	1,330,393	26,574,000
1878	2,451	374	919,575	20,576,000	1,055	88,727	2,760,000	1,008,413	23,330,000
1879	3,379	440	1,447,154	28,639,000	1,113	93,889	2,582,500	1,585,462	31,222,000
1880	2,379	487	1,159,039	23,729,000	1,256	92,185	2,843,000	1,267,296	26,672,500
1881	1,975	445	880,505	21,467,500	1,107	92,233	2,398,000	972,739	23,731,000
1882	1,806	615	1,111,628	23,498,000	991	84,198	1,990,000	1,195,843	26,888,000
A.v. transport.	2,622	448	1,176,991	23,782,000	1,064	89,357	2,501,000	1,266,348	26,283,000

An examination of the above table should call especial attention to the following facts:

First. That during the period from 1855 to 1866 the largest freightage brought to Rybinsk was in the year 1857, and amounted to 1,002,278 tons; during the period from 1867 to 1875 the largest freightage was in the year 1875, and amounted to 1,390,130 tons; and during the period from 1876 to 1882 the largest was in the year 1879, and amounted to 1,585,462 tons.

Second. That the smallest freightage during the period 1855 to 1866 was in the year 1860, and amounted to 559,607 tons; that the smallest in the next period above mentioned was in the year 1868, and amounted to 930,600 tons, and in the last period the smallest freightage was in the year 1881, and amounted to 968,400 tons.

Third. That the average quantity of goods shipped from Rybinsk in the direction of St. Petersburg during these periods was as follows: From 1855 to 1866, 828,723 tons; from 1867 to 1875, 1,158,252 tons; and from 1876 to 1882, 1,266,348 tons.

In the absence of the foregoing figures it would be difficult to believe that the quantity of goods transported has increased by 433,929 tons during the last 28 years, and that in the last 7 years the transports have been increased by 112,500 tons.

THE RYBINSK WHARF.

The Rybinsk Wharf is the great central collecting point of the Volga districts, where are gathered together the cereals and other agricultural products, the varied mineral wealth of Russia, such as iron, copper, coloring matters, naphtha, also salt, wood, bristles, wool, tallow, hides, furs, and fish. These goods are largely forwarded to St. Petersburg to be sent to other countries, a small proportion only of the cereals being directed to the nonproductive provinces of the north. It is therefore important, both to the consignor and to the consignee, that this merchandise be transported as quickly and as cheap as possible.

The following tabulation will give some idea of the relative value of the canals and the railroad in handling this freight:

Canals.	No. of vessels.	Average freight per vessel.	Total freight.	Transshipments from Rybinsk.
1856-1866.				
		<i>Tons.</i>	<i>Tons.</i>	<i>Per cent.</i>
Marie	2,478	161	401,175	53
VishniVolodsk	2,777	93	266,255	25
Tikhvinsky	1,618	29	49,885	7
Total	6,873		717,283	95
1866-1875.				
Marie	2,763	209	576,370	55
VishniVolodsk	2,358	93	228,166	22½
Tikhvinsky	1,224	29	36,932	2
Total	6,345		841,467	79½
1876-1882.				
Marie	2,230	241	550,687	47
VishniVolodsk	1,417	93	141,075	12½
Tikhvinsky	721	29	22,195	1½
Total	4,368		712,750	60½

Rybinsk and Bologoe Railway.

Description.	1866-1875.	1876-1882.
Independent of canals.....tons..	145,254	375,943
Percentage exported.....	14 $\frac{1}{2}$	32
Goods necessarily wintered at Rybinsk.....tons..	50,186	87,975
Percentage of total receipts.....	5	7 $\frac{1}{2}$

Exports from Rybinsk without transshipment—1873-1882.

Via—	No. of vessels.	Average freight.	Total.
		<i>Tons.</i>	<i>Tons.</i>
Marie system	364	177	64,428
Vishnivolodsk system.....	155	64	9,920
Tickhivinsky system.....	174	22	3,828
Total	693	.....	78,176

The general transports during the years of the last period, from Rybinsk, were as follows:

Via—	Tons.	No. of vessels.
Marie system	615,808	2,594
Vishnivolodsk system.....	150,075	1,572
Tickhivinsky system.....	26,100	896
Total	791,983	5,062

Rybinsk-Bologoe Railway.

	Freight.	No. of wagons.
	<i>Tons.</i>	
Direct from vessels.....	375,948	38,986
From stores and manufactured goods.....	90,129	9,123
Total	466,072	48,109

THE VISHNIVOLODSK SYSTEM.

Since the inauguration of the Rybinsk-Bologoe Railway the transport of goods on this system has gradually decreased. Thus, according to the calculations of 1855-1866, it transported 265,178 tons of goods; for the period 1867-1875, it transported 225,000 tons; for the year 1877, 176,786 tons; in 1878, 1879, and 1880, 128,571 tons for each year; for 1881 the transport was 73,768 tons; and in 1882 it was 77,040 tons; so that at present the transport of goods from Rybinsk by this system has nearly ceased, and such goods as are sent by this canal are intended for neighboring supplies or go to Tver, whence they are brought to St. Petersburg by the Nicholas Railway; the latter transportation occurring only when Rybinsk is so embarrassed with freight that the Marie Canal and the Rybinsk-Bologoe Railway are unable to handle the freight. But this system is an expensive means of transport, for although the

goods are only from 12 to 14 days on the canal, by the time they arrive at St. Petersburg by rail the transports cost $9\frac{1}{2}$ cents per 36 pounds.

The reasons why the direct transport of goods from Rybinsk to St. Petersburg has been abandoned are the following: The cost of transport would now actually cost from 13 to 14 copecks per pound, and adding to this the other necessary expenses calculated in the Marie system, the real cost per 36 English pounds, by the time they arrived at St. Petersburg would be $8\frac{1}{2}$ or 9 cents; again it takes even longer than on the Marie system, the journey being from 40 to 80 days, and even more.

THE TICKHVINSKY SYSTEM.

Direct transport of goods on this system, from Rybinsk to St. Petersburg, has also almost ceased since the construction of the Rybinsk-Bologoe Railway. Not more than 16,071 tons are transported at present from Rybinsk and these are for local needs. The cost of transportation by this canal from Rybinsk to St. Petersburg would amount to from 7 to $8\frac{1}{2}$ cents, and with the other expenses would be from 9 to $10\frac{1}{2}$ cents per 36 English pounds. It could not transport more than 48,214 tons during the navigable season and vessels would be from 15 to 25 days on the road.

RYBINSK AND BOLOGOE RAILWAY.

Comparing the rapidity of transports by rail, without doubt the railroad has the preference over the canal system. For example, if we allow the most rapid transport by the Marie Canal from Rybinsk to St. Petersburg, it would still take from 18 to 26 days; whereas by rail it would take from 4 to 6 days. It is, therefore, comprehensible that a certain portion of goods which can permit an extra expense of $1\frac{1}{2}$ cents per 36 English pounds will always apply to the railroad for transit.

The railroad also brings to St. Petersburg such goods as have been left on account of the closing of navigation. On the other hand, however, if the railroad between Rybinsk and St. Petersburg were organized, it could never answer the purpose so well as a well-organized canal system. For example, it has not the means of transporting at a given time what would be required. As will be shown below, the average receipt of goods at Rybinsk for the last 7 months was 1,253,571 tons, received as follows:

Month.	Receipts.	Average receipts.	
	Per cent.	Per cent.	Tons.
April.....	4-6	5	62, 678
May.....	30-50	40	501, 428
June.....	30-40	35	438, 304
July.....	8-12	10	125, 357
August.....	5-7	6	75, 214
September.....	2-4	3	37, 067
October.....	$1-1\frac{1}{2}$	1	12, 983
		100	1, 253, 571

It is impossible to obtain the average monthly transports by the Rybinsk Bologoe Railroad for the last few years, but taking the year 1877, when the railroad made the largest transports, namely: both ways, 781,071 tons, in which are included 498,214 tons of goods taken directly

from the vessels at Rybinsk. Transports by train directed towards Bologoe during that year may be represented as follows :

Months.	No. of trains.	No. of wagons.	Tons.	Per cent.
April	94	3,268	31,339	2½
May	265	12,967	125,039	10
June	352	12,396	119,633	10
July	420	14,841	143,109	11½
August	331	11,760	113,561	9
September	301	10,229	98,734	7½
October	246	8,230	79,360	6½
Total				57

CANAL VS. RAILWAY TRANSPORTATION.

Taking these figures as a basis, at the end of September the railroad would only have transported the goods which were received at Rybinsk at the opening of navigation on the first days of June, and at the end of October there would still be remaining 43 per cent. of the goods received at Rybinsk ; thus the goods would have been delayed at Rybinsk from ten to one hundred and fifty days, or on average, each 36 pounds of goods would be delayed at Rybinsk at least sixty days.

The cost of transportation per Rybinsk-Bologoe Railway is, according to the tariff, 11½ copecks per 36 English pounds ; to which must be added 3 copecks for freighting and unloading, 2 copecks for tare and waste, and at least 1 copeck for storage at Rybinsk, thus making a total of 17½ copecks per 36 English pounds.

The Marie system, from the Caucasus to the Baltic Sea, runs through sixteen cereal-growing and industrial provinces, and extends over 6,666 miles with its tributaries. Of this system between Rybinsk and St. Petersburg, 600 miles are covered by a natural waterway ; there only remain 133 to be constructed artificially to make it one of the most important canals in the world.

The natural portions of this system are :

To Rybinsk : The Scheksnal, from the Volga to the White Sea, 266 miles, of which 220 miles are naturally navigable ; the White Sea, 23 miles ; the Kovia, 23 miles. From Rybinsk to St. Petersburg : The river Vuitgree, 14 miles ; the Onega Lake, 20 miles ; the River Svir, 100 miles ; the Ladoga Lake, 106 miles ; the river Neva to St. Petersburg, 40 miles ; and further, the open sea.

The geographical position which the Marie system occupies resembles that of the Panama Canal. But all this is insufficient for the demand of goods waiting to be transported, and there is a general stir and murmur on all sides.

The flotilla of the Volga consists of 600 steamers, 2,000 barges, 1,100 sea vessels on the Caspian, not including a quantity of smaller boats and larger vessels of old construction on the Volga. It is perhaps the largest interior flotilla in the world, and with all that it can not do the work. For example, when an extraordinary harvest in the Volga districts has placed 1,000,000 to 1,500,000 tons of cereals on the wharves at Rybinsk, there is a universal anxiety ; all the grain exporters are impatient to get their goods off at the head of the caravan. This mass of goods arrives at Rybinsk from the 1st of May to the 20th of June.

Some shippers hasten to avail themselves of the railway, being afraid to lose the sale of their goods, preferring to take less profit.

The reasons why everybody hurries his goods to Rybinsk apart from those already stated, are: First, after June 10th to 20th the water in the Volga generally becomes low. Second, it is necessary to hurry the dispatch of cereals from Rybinsk to St. Petersburg, in order that they may arrive in the months of June and July, as already in August the rates of freight and insurance are increased threefold over those of June and July. Third, American cereals of the new crops begin to reach Europe in September, whereas the last Russian crops can with difficulty, during the whole navigation, scarcely arrive at the markets for sale. Fourth, to transport the cereals from the Volga by rail, for reasons shown above, means a heavy loss to the farmer or to the shipper.

The Marie system can transport from the Volga to St. Petersburg about 642,857 tons; the dispatch of boats from Rybinsk terminates during the month of June, and the arrivals at St. Petersburg are approximately as follows:

	Tons.
June	160,714
July	192,857
August	160,714
September	128,571

The Rybinsk-Bologoe Railway transports about 401,785 tons, the arrivals in St. Petersburg being about as follows:

	Tons.
May	80,357
June	112,500
July	112,500
August	64,285
September	32,143

Finally, next to the two principal roads are situated three other canals.

The Kiekhvinsky and Vishnivolodsk systems, also the Volga at Tver; but these are not effective. The three canals transport to St. Petersburg, at the utmost, 160,714 tons; the remaining 80,357 tons brought to Rybinsk are distributed among the neighboring towns.

It thus appears with what difficulty the five roads can transport to St. Petersburg the products of an ordinary year. Therefore it is with universal applause that the Russian Government has decided to improve the Marie system even at any expense, and to such an extent as will enable it to transport with facility and dispatch the fruits of a welcome harvest.

IRRIGATING CANALS.

On this important question but little can be said in this report, inasmuch as no reliable data can be found touching this matter. In the study of the navigable canals, especially the Mariensky, Tickvinsky, and the Vishnivolodsk systems, and of the arguments tending to show why they should be improved and enlarged, I have come across here and there many statements bearing upon this method of irrigating the lands in different parts of Russia; but as the bureau of statistics has only studied this matter for a few years past, and as these studies are very superficial as yet and meager in detail, little of value has been learned regarding the subject.

I have heard in a general way that there is a small irrigating canal in the Caucasus, worked by a private corporation, and which is reported to be on the eve of failure. I have been informed on semireliable authority that the irrigating canals of central Asia, situated in the cotton-

growing districts, are being very considerably extended and improved; but the bureau of agriculture is without any statistics touching them, and I regard the question as too important to be discussed in this report in the absence of official figures. I am aware that surveyors and experts have been sent by the Russian Government to the United States to study the practicability and value of such canals in operation there, and I am able to say that many plans of improvements thus learned have been adopted by the Russian authorities.

I shall take pleasure in continuing the study of this interesting subject, and if I should obtain any official information on the question that would be likely to be valuable to the Department, I shall be glad to incorporate it in a supplementary report.

J. W. CRAWFORD,
Consul-General.

ST. PETERSBURG, *February 15, 1890.*

FINLAND.

REPORT BY VICE-CONSUL DONNER.

The principal canal in Finland is the Saima Canal, which connects the numerous inland lakes with the Gulf of Finland at the town of Wiborg. The extent of the canal is 55 versts (35 English miles), the lowering of the water, which is 255 feet above the sea level, is effected through the medium of 28 locks, all of which have a length of 120 feet each, a breadth of 25 feet, and a depth of 9 feet, and are built of cut granite. The construction of the canal, which is worked partly through granite rocks and partly through ordinary ground, was commenced in 1845, and was finished in 1857, at a total cost of over 12,000,000 Finnish marks.

The second canal of importance is the Pielis elfs Canal, which has also a length of 55 versts, and connects the lakes with the Saima Canal system through ten different stations and locks of similar construction with those of the Saima Canal.

The cost has been 2,500,000 marks. There are, further, ten smaller canals in different parts of the country, connecting the smaller lakes. Several of the locks of these canals are constructed of wood.

The traffic on the Saima Canal was, during 1887, carried on by 3,464 crafts and steamers, and the total income was 425,000 marks, with a working expense of 105,000 marks, or net 320,000 marks. The total traffic of all the other canals amounted to 100,000 q, with an expense of 95,000 q, or net only 5,000 q.

The traffic on the canals is carried on generally from the middle of May to the middle of November, when ice generally sets in. The canals have to a great extent assisted and increased the export of the resources and produce of the country, which consist chiefly of timber and some farm produce.

The canals are administered by the government. The Saima and the Pielis elfs canals have their separate managers, cashiers, and book-keepers. All the other canals are managed each by a cashier and book-keepers.

HERMAN DONNER,
Vice and Acting Consul.

UNITED STATES CONSULATE,
Helsingfors, August 23, 1889.

SWEDEN.

REPORT BY CONSUL MAN, OF GOTHENBURG.

A glance at the map of middle and southern Sweden will suffice to show an observer that the formation of the country is peculiarly favorable to the opening of canal ways, as it is dotted with lakes and traversed by small rivers. Two of these lakes, Venern and Vettern, are extensive bodies of water, Lake Venern being 94 miles long and 43 miles wide, and ranking as the third largest lake in Europe, while Vettern is 72 miles in length by 18 in breadth.

The people of Sweden 3 or 4 centuries ago saw the advantage of cutting a way between these chains of lakes and water courses, and thus connecting them with each other and the seacoasts.

As long ago as 1617 the first important work of this kind was begun, while the latest undertaking was completed in 1871.

The canals constructed during this period furnished the earliest mediums of communication and traffic, and not only proved of great convenience and profit in the early days when railroads were unknown, but have continued their popularity and usefulness up to the present time, when they are traversed by innumerable craft of every description, from the humble ore and lumber barge to the elegant passenger steamer.

The following is a list of the principal completed canals of Sweden: Trollhättan Canal and improvement of the Göta River, completed in 1800; rebuilt 1836-1844, at a cost of \$603,000, furnished by the state.

Göta Canal: Connecting lake Venern with the Baltic, commenced in 1811, finished in 1832; 54 miles in length, and costing \$4,154,000.

Strömsholm Canal, connecting lakes Mälaren and Barken. Commenced 1777, rebuilt 1840-1860. Length 68 miles, 7½ miles of it cannal. Cost \$50,920, furnished by the state.

Södertelge Canal, connecting lake Mälaren with the Baltic, built 1806-1819. Length 2 miles. Cost \$214,400.

Dalsland Canal, connecting lakes Venern and Stora Lee, built 1865-1868, at a cost of \$361,800, of which \$53,600 was furnished by the state.

Kinda Canal, connecting lakes Roxen, Reugen, Jernlunden and Åsunden, completed in 1871, at a cost of \$482,400.

TROLLHÄTTAN CANAL.

The need that furnished the impetus to the idea of constructing this, the first Swedish canal, the inspiration to which is said to have sprung from Swedenborg's fertile brain, was the establishing of a perfect connection between the great lake Venern and the Göta River to the sea.

The Göta River was already the natural outlet of Lake Venern, but near its source it was rendered completely unnavigable by rapids and a sharp descent of 144 feet within a distance of 1 mile.

To avoid these natural hindrances an artificial water course was begun during the reign of Charles XII, upon the return of that monarch from his long adventurous sojourn in foreign countries. After his death the work ceased for a time, but was taken up again, and eventually, after many difficulties and interruptions, was successfully completed in 1800, thus crowning the perseverance of 200 years with the final estab-

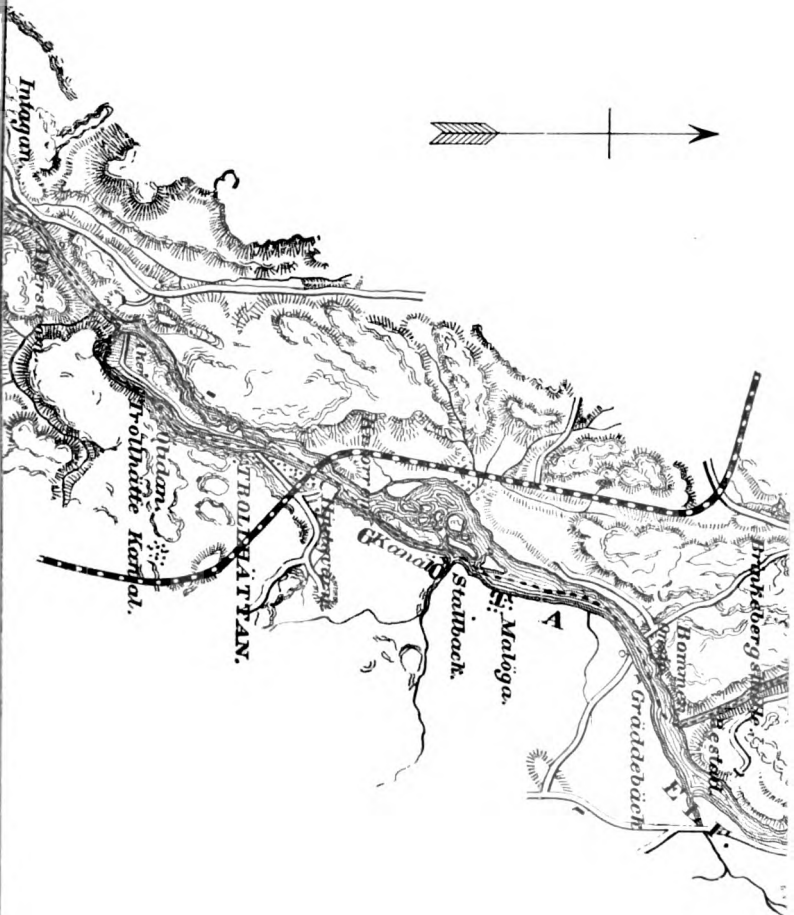
CANALS IN SWEDEN.

NEW TROLLHÄTTAN CANAL

(IN ITS ENTIRE LENGTH.)

FROM VENERSBORG TO THE GÖTA RIVER

(From Barois.)



lishment of a long-needed and valuable connection between Lake Venern and the North Sea.

It was owing to the opening of this canal that Gothenburg, situated at the mouth of the Göta River, became the leading commercial city of the Kingdom.

The character of the work upon this canal was difficult in the extreme, owing to the natural formation of the land in the locality, which presented a steep descent toward the sea, and a solid mass of red granite rock, through which nearly the entire canal and its fifteen locks were constructed.

In connection with this work there was the dredging and improving of the river, which, together with the canal, represented a stretch of 60 miles.

The nature of this undertaking, with the manner of its execution, may be more fully understood by a reference to the accompanying drafts. The locks therein represented are built of dressed granite, and the gates consist of heavy iron framework planked with wood.

The usefulness of the Trollhättan Canal may be judged from the fact that over 6,000 vessels pass through these locks annually.

THE GÖTA CANAL.

A navigable water way having been opened from Venern westward to the North Sea, it still remained to carry on the work eastward to the Baltic, thus uniting the two seas by supplying canals as links in the chain of lake stretching across the country.

The most important canal in Sweden, the Göta Canal, was then commenced in 1811 and completed in 1832, not having met with the financial and other extraneous drawbacks experienced by the first canal enterprise.

The excavated and blasted portions of this canal measure 54 miles, while the distance between the two extremities, including both artificial and natural water courses, covers 115 miles.

Its highest elevation lies 308 feet above the Baltic, and 163 above lake Venern.

It has fifty-eight locks, each of which is 121.36 feet long, and 22.96 feet broad.

Thirty sliding iron draw-bridges span it at the road crossings, and it has eleven harbor basins.

Its mean depths is 9.84 feet, and it is 49.50 feet broad at the bottom, and 85.28 feet at the surface.

The construction of the Göta Canal was not without its technical difficulties, owing to the great amount of granite encountered, which made its course somewhat deviating in places, and also to morass, the latter necessitating filling in, in order to create a firm foundation for the bottom of the canal, or the forming of a sort of aqueduct.

The canal, where the nature of its banks require it, is paved at the sides with stone a few feet below and above the water level, and planted with a hedge above the stone work, to protect the banks from the washing and undermining action of the waves made by the passing steamers, a fine and luxurious line of which ply regularly between Stockholm and Gothenburgh every season, carrying large numbers of passengers, many of which are American tourists.

These two canals—Trollhättan and Göta—with their seventy-four locks, perfect the water way across the peninsula, from the Baltic to the North Sea, which in its entirety amounts to 255 miles.

The other canals mentioned—Strömsholm, Södertelge, Dalsland, and Kinda—are merely to connect other lakes in the interior with the water ways opened up by the Trollhättan and Göta Canals.

Strömsholm Canal, connecting the northern provinces with Lake Mälaren and Stockholm, furnishes a water way 63 miles long, $7\frac{1}{2}$ miles of which is a canal of $7\frac{1}{2}$ feet depth, with twenty-five locks, and an elevation at its highest point of 361 feet above the sea level.

Södertelge Canal, joining Lake Mälaren with the Baltic, is 2 miles long, 30 feet wide at the bottom and 60 feet at the surface, and has a depth of 12 feet. It is cut through sandy hills, some of them 100 feet high.

Dalsland Canal, connecting Lake Venern with a number of narrow fjord-like lakes near the borders of Norway, possesses four locks and an iron aqueduct 118 feet long and 16.40 feet broad, which conducts the canal over a water fall, and altogether measures $3\frac{1}{4}$ miles in length.

The Kinda Canal, connects a chain of small lakes near the southeastern coast, with the Göta Canal, and is $49\frac{1}{2}$ miles long. It has fifteen locks 98.40 feet long, by 16.40 feet broad, and 5.57 feet deep.

Most of the work on these canals was mere manual labor, without the assistance of excavating machinery and other mechanical appliances familiar to modern engineering, and therefore is of little value as to detailed method, incalculable as the benefit of the completed structures have been, and are.

The two canals furnishing a water route across the kingdom have naturally held the railroads in check, moderating excessive tendencies, and otherwise proved invaluable to the country.

They are all owned by stock companies, and their management is similar, consisting of a president, four directors, a chief engineer, lock inspectors, two canal constructors, a traffic chief, and other subordinate officers.

Sweden has no irrigating canals, no necessity for them existing here

Statement showing, by months, traffio and amount of toll collected on Göta Canal during the year 1888.

Months.	Number of sailing vessels.	Number of steam vessels.	Amount of toll collected.
May 10 to 31.....	391	89	\$5, 476. 70
June.....	682	175	10, 608. 57
July.....	724	179	10, 908. 21
August.....	681	179	10, 696. 42
September.....	613	159	8, 077. 78
October.....	361	133	6, 102. 47
November.....	176	90	3, 155. 03
December 1 to 15.....	35	8	229. 13
Total.....	8, 663	1, 012	55, 249. 31

Statement showing merchandise carried by sailing vessels on Göta Canal, during the year 1888.

Articles.	Amount.	Articles.	Amount.
Breadstuffs.....kilos..	2, 929, 822	Ore.....kilos..	5, 768, 573
Coal and coke.....hectoliters..	251, 743	Ore zinc.....do....	20, 020, 985
Iron and steel.....kilos..	3, 245, 883	Pittprops and wood...cubic meters..	74, 395
Lumber.....cubic meters..	26, 356	Stone.....kilos..	5, 948, 808

Statement showing traffic and amount of toll collected on Göta Canal, during the years 1879 to 1888.

Years.	Sailing vessels.		Steam vessels.	
	No.	Toll.	No.	Toll.
1879.....	2, 076	\$17, 654. 50	698	\$23, 981. 71
1880.....	3, 522	19, 914. 27	905	24, 906. 31
1881.....	3, 539	18, 631. 09	898	24, 096. 18
1882.....	4, 272	22, 358. 17	1, 034	34, 850. 10
1883.....	4, 332	22, 670. 39	1, 032	35, 082. 54
1884.....	3, 893	20, 313. 33	1, 145	36, 281. 04
1885.....	3, 588	20, 116. 08	1, 122	38, 481. 50
1886.....	3, 797	23, 191. 92	1, 209	40, 174. 20
1887.....	3, 869	23, 555. 32	1, 025	34, 729. 94
1888.....	3, 663	21, 652. 05	1, 012	33, 593. 26

Statement showing traffic and amount of toll collected on all the canals in the kingdom during the years 1884, 1885, and 1886.

	1884.		1885.		1886.	
	No. of trips.	Aggregate amount of tolls.	No. of trips.	Aggregate amount of tolls.	No. of trips.	Aggregate amount of tolls.
Vessels.....	68, 081	\$233, 443. 54	69, 329	\$242, 706. 96	69, 318	\$253, 441. 51
Frollhättan Canal.....		76, 218. 16		78, 046. 42		83, 851. 84
Göta Canal.....		56, 594. 37		58, 607. 58		63, 366. 12

ERNEST A. MAN,
Consul.

UNITED STATES CONSULATE,
Gothenberg, October 30, 1889.

THE UNITED KINGDOM.

CANALS COMMUNICATING WITH LEEDS.

REPORT BY CONSUL WIGFALL.

EARLY ENGLISH CANALS.

Traces of legislation with a view to facilitating communication by means of water ways are discoverable in England as far back as the reign of Henry I; who, in the year 1121 is supposed to have caused the Fossdike Canal (called an ancient Roman work) to be scoured out for the purpose of opening a navigable communication between the Trent and the Witham at the city of Lincoln, so that that place, which was then in a very flourishing state and enjoying an extensive foreign trade, might reap all the advantages of a more ready communication with the interior.

This was in 1121. Time's irony could scarcely be more keenly marked. The foreign trade of Lincoln is no longer extensive. The city is chiefly known to-day, and to the outside world, for its relics of the past, its magnificent cathedral and other heirlooms of departed greatness; but the Fossdike is there still. It is 11 miles long or thereabouts and level through its course. Despite its old age, it gives no evidence of senility, but bears the barges which bring to the good citizens of Lincoln their coals with a surface as serene and equable as when, in the days of Ed-

ward the Confessor, the King's monnetari at Nottingham had the care of the river Trent and of the Fossdike and of the navigation therein.

One of the earliest of the English canals was also in that district, the Caerdyke, cut by the Romans to connect the river Nene from a point near Peterborough in Northamptonshire with the river Witham 3 miles below Lincoln. This work was some 40 miles in length. It has been disused for centuries.

The Fossdike would appear to have been a prolongation of the Caerdyke; and the combination suggests perhaps as vividly as any the mode of origin and development of the canal system in this island.

The first canal seems merely to have been for supplements to the already existing water courses; they were not independent works intended to supply a separate method of transportation.

As the Caerdyke led from the river Nene near Peterborough to the Witham below Lincoln, and the Witham was joined by the Fossdike to the Trent at Torksey whence the Trent empties into the Humber, one of whose affluents is the Ouse, this apparently trifling length of 11 miles of the Fossdike navigation was or might have been the completing link in an inland course from Northamptonshire to York, which was the capital of Roman Britain. It remained for a much later date for the chain to be taken up and borne by the Aire and the Calder from the Ouse to Leeds and Wakefield and thence by other canals across the Pennine Hills to Manchester, Liverpool, and the Irish Sea.

During the twelfth and the succeeding centuries, up to the sixteenth, little attention was apparently paid to the opening of new channels of traffic by water; and, indeed, until the eighteenth century no widely spread endeavor manifests itself to add to the natural routes supplied by the various creeks and rivers.

Previously to the last named period the efforts of those public spirited persons who were interested in improving the transportation facilities of the country side were limited, as a rule, to the opening of river channels and the utilizing of water ways provided by the natural courses.

The eighteenth century had nearly closed before the making of proper canals received the impetus which has resulted in covering the face of England with that network of artificial water ways which supplements to-day the far more extensive and varied railway system. The years that saw the gestation of the revolution in France, which found England perfecting her hold on India and in the same moment feeling slip from her grasp the still more mighty possibilities of her American possessions, were filled with a spirit of unrest and innovation, which made itself manifest in many ways. It was during these troublous times, when steam as a motive power was struggling to existence, when the application of electricity had been but vaguely dreamed of, a period when men's minds were shaken with political doubts, and when moral and religious precedents were suffering assaults scarcely till then paralleled; it was in this time that the material energies of the kingdom came to a similar awakening.

One of the manifestations of this new-born activity was that which sought to perfect the means of transportation between the various trade and population centers which thus far had remained so ill-provided.

The two plans which found most favor among engineers were adaptations of long and well known methods. The one was the tramroad of the mines, so afterwards magnified and altered as hardly now to be capable of recognition in the railway, the other was the slower and less changeful development of a still older mode of transport, the water ways which nature's hand had built.

EARLY ENGLISH RAILWAYS.

The historical account of the navigable rivers, canals, and railways throughout Great Britain, compiled by Joseph Priestley, and published in the year 1831, gives something like sixty separate titles of railways then constructed or projected. It will of course be well understood that these were vastly different in length, capacity, and fashion of working from their successors of the present day.

The writer has in his possession a photograph of one of the early trains, taken from an engraving of the year 1812, and representing the occasion when, to quote from an inscription written upon the print, in a hand more bold than elegant:

June 24, 1812, the fly engine come to the Bird in hand and Leeds with 8 waggons.

The "fly engine" presented has a large cog-wheel at one side, which, engaging in a row of teeth laid along the track, propels the engine and the "8 waggons" attached to it at the rate, we are further told, of "3½ miles an hour on a level railroad." What its capacity for speed might be on a steep grade is left to be conjectured.

The three score railroads existing or contemplated in 1831 were not very far advanced in facilities beyond the 3½ miles an hour fly engine; although the Rocket locomotive had been turned out by Stephenson in 1829, and the months in that era were capable of counting progress with the years which had preceded it.

These railroads of 6 and 10 miles in length, as already indicated, had been adopted from the tramways of the coal mines; and they were operated first by horse-power, and later on by machines such as the "fly engine" of the Middleton road here at Leeds referred to above. They were soon, however, to be developed into the 1,500 and 2,000 mile lines and the 60-mile speeds which have come after them. Little more than three-quarters of a century has passed since the Middleton fly-engine was deemed worthy of having its portrait made; and railroads are now quite other than they were. Their elder sisters, the canals, however, have had no such progress. In many cases they remain to-day essentially as they were left by the men who constructed them. A witness before the select committee on canals in 1883 says the existing canals were constructed when railways were unknown, and are entirely behind the needs of the times; and that they must be improved before they can compete with railways. Another witness states that the locks and water ways of canals are altogether wanting in uniformity; scarcely two canals have a common gauge. Even on the same canal there may be two or three different gauges of locks. Almost every engineer who made a canal seems to have adopted a different gauge, although they may form portions of a continuous route.

With such conditions as are set forth in this evidence and elsewhere, the short links originally built for merely local use, the irregular and in many instances the insufficient dimensions which often even now remain unaltered, the lack of coöperation in management following on the divided ownership, and the absence of through routes—some or all of these elements separately or in combination have sufficed to exercise a malefic influence to interfere with and sometimes to prevent the profitable operation of these water ways.

THE AIRE AND CALDER NAVIGATION.

A more satisfactory issue has been attained in exceptional instances. One of the most important, successful, and well-established of these un-

dertakings in England is also one of the oldest. In a review of the development of canals connected with the town and district of Leeds, the Aire and Calder navigation comes naturally to the front. A description of this association, its origin, formation, and progress may perhaps better than any other example serve as a type to indicate and explain the inception and development of English canals. It was begun 50 years before the initiation of regular canal building, as a navigation company; it was in the front rank of the regular canals when regular canal building was entered on; its administration has been wise and energetic, thoroughly abreast with the times, and not only willing but able to meet difficulties as they arose, and by improved construction and appliances place the canal where it now stands.

The author Priestley, from whom I quote, says of the Aire and Calder :

The rendering these rivers applicable to the purposes of commerce forms one of the most important features in the history of our inland navigation, and as they were made navigable under an act of Parliament passed above 50 years prior to the date of any enactment for a canal navigation, a brief outline of this extensive and useful undertaking may not prove unacceptable to our readers.

The first act of Parliament given is that of 10 and 11 William III, May 11, 1699. An attempt in the same direction had been made in 1625, in the first year of Charles I, when a bill was introduced into the Commons for the making and maintaining the rivers of Ayre and Cowldes in the West Riding of the Countye of Yorke navigable, etc.

This bill, after a long debate, was rejected, and more than 70 years elapsed before the project was renewed. In 1698 Lord Fairfax introduced a similar bill into the House of Commons, and the next year, 1699, the act passed the Upper House and received the Royal assent. It may be noted here that petitions in favor of the bill were numerous, coming from towns as far apart as Lincoln and Manchester, and signed by magistrates, aldermen, and burgesses. Against the bill appeared the petition from the lord mayor and the commonalty of York, and also the private petition of Francis Nevill, of Chevet, esquire, the owner of the Soke Mills at Wakefield.

The causes assigned by these hostile petitioners were singularly antithetical in the reasons mentioned, though inspired by motives equally unaltruistic. The corporation of York say the river Ouse will be drained of its water and its trade together, while the owner of the Soke mills states that—

By backwater his mills will be inevitably stopped from going at all, to his great prejudice.

So that, what with going away altogether and not going at all, both the city of York and Mr. Nevill were opposed to the Aire and Calder.

The conditions of the period are markedly shown by the petitions.

Leeds prefers a statement to the effect that "Leeds and Wakefield are the principal trading towns in the North for cloth," and further "the petitioners having no convenience of water carriage within 16 miles of them, which not only occasions a great expense but many times great damage to their goods, and sometimes the roads are impassible, etc." The clothiers of Ratchdale say that they are "40 miles from any water carriage." The clothiers of Halifax state that "they have no water carriage within 30 miles and much damage happens through the badness of the roads by the overturning of carriages." The clothiers of Wakefield repeat the statement made from the Leeds petitioners of their united importance as cloth markets, complain that they have to send their goods 20 miles by land carriage, "the expense whereof is not only very chargeable, but they are forced to stay 2 months sometimes while the roads are passible to market, and many times the goods re-

ceive considerable damage through the badness of the roads by overturning."

The act of William III authorized making the river navigable to the tideway. The Aire takes its rise in the Craven district of Yorkshire, out of Malham Farm, a few miles east of Settle, which latter place is situated about 60 miles west of York, 50 miles north of Manchester, and something less than 40 miles in a northwesterly direction from Leeds.

The Aire in its course leaves Bradford 3 miles to the south, and, running directly through Leeds, unites with the Calder at Castleford. From the junction, still being called the Aire, the river proceeds to the Ouse, into which it empties a short distance above the port of Goole; and thence, receiving the waters of the Trent somewhat lower down, forms the river Humber, upon which, at its junction with the smaller river of the same name, the important seaport of Hull is situated. The authority of the first act extended only to Weeland, a point on the Aire above its junction with the Ouse and presumably the head of the tideway. The subsequent continuation of the navigation to the Ouse was made under a later act which went into effect June 14, 1774.

The navigation of the Aire at the date, 1831, of the publication quoted from, began at Leeds and extended to the junction with the Calder, a distance of about $11\frac{1}{2}$ miles; in which there was a fall of $43\frac{3}{4}$ feet by six locks.

From the junction to Weeland was $18\frac{1}{2}$ miles, with 4 locks and a fall of $34\frac{1}{2}$ feet. At a little distance above Leeds Bridge, where the wharves of the Aire and Calder navigation are situated, is the basin of the Leeds and Liverpool Canal, which locks down at this point into the river Aire and thus connects the two navigations.

The source of the Calder is near Todmorden, a town 20 miles north by east from Manchester, and 61 miles southwest from Leeds, at the border of the counties of York and Lancaster, and among the Pennins Hills. These last named form what is popularly termed "the backbone of England." In the same field the West Calder, or a branch thereof, takes its rise, and flowing in an opposite direction joins the Ribble and empties into the Irish Sea. The Pennins Hills are a range coming down from the high lake country of Westmoreland and culminating at the Peak in Derbyshire, separating the watersheds of the two seas, and forming a by no means inconsiderable obstacle to any undertakings which, like railroads or canals, are dependent upon the maintenance more or less approximately of a level gradient in the trajet of their lines. It is through and over this chain of hills that all railways and canals connecting the North and the Irish Seas (or, to designate the points more definitely, Hull and Liverpool) have to be conducted.

The Calder, rising near Todmorden, runs in an easterly direction, passing near Halifax and through Dewsbury to Wakefield and on to its junction with the Aire at Castleford. The navigation began at Wakefield, and in the $12\frac{1}{2}$ miles to Castleford the level dropped $28\frac{1}{2}$ feet by four locks. The total length of the navigation from Wakefield to Weeland was, in 1831, a distance of $31\frac{1}{2}$ miles, and the fall $62\frac{3}{4}$ feet. Just below Wakefield bridge the Calder and Hebble navigation begins, and half a mile below Wakefield the Barnsley Canal locks down into the river Calder. Since that time the Barnsley Canal has been acquired by the Aire and Calder; and the Calder and Hebble was operated by the Aire and Calder for a number of years under lease, which has now expired.

At the date of Mr. Priestley's publication, short canals and railroads,

the property of private individuals, were connected with and served as feeders to these navigations, for transporting the lime, gypsum, coal, and so forth, the produce of the various estates. One of these railroads is mentioned as bringing 40,000 to 50,000 tons of coal, and another from 70,000 to 100,000 tons per annum to the river. It was on one of these, it may also be noted, that the fly engine of 1812 was used.

To revert to earlier days, it appears that upon the passing of the enabling act in 1699 a sum of about £12,000 (\$38,398) was advanced by the undertakers of the Aire and Calder, and that in the course of a few years more sundry additional small amounts were provided to the extent of some £16,000 (\$77,894), which were lent and advanced. These sums, together with the whole of the income derived from the tolls during the first 24 years' operations, were laid out in completing the works. So inconsiderable was the trade of the district that as late as 1730 the whole property of the navigation was rented for £2,000 (\$9,733), the undertakers themselves agreeing to be at the risk of keeping all dams on the rivers good against accidents. In 1771 increased demands of trade led to the projection of an entirely new canal from Leeds to Selby on the Ouse, 20 miles east of Leeds and 14 miles south from York. This was surveyed, but being opposed by the Aire and Calder navigation, the plan failed. It was in consequence, nevertheless, of this application and of several memorials addressed to themselves by merchants and by others interested, that the Aire and Calder undertakers applied for and obtained a second act, which has already been referred to and which was passed in 1774, enabling them to make a canal from Haddlesey on the Aire navigation across the angle separating the two rivers to Selby on the Ouse; and also to improve the river Aire from Weeland down to the Ouse. Various betterments were shortly afterwards made under this act; and on April 29, 1778, the canal was opened from Haddlesey to Selby. These and other alterations cost so much as to entail a debt upon the concern of about £70,000 (\$340,655).

Since the year 1800 very considerable sums had been expended in additional locks, in the purchase of premises, and in dock and warehouse building and other improvement of the property.

The canal from Haddlesey to Selby was about 5 miles long and had but one lock, that into the tideway of the Ouse at Selby. From Leeds to Selby was about 30½ miles by this line of canal, with 10 locks; and from Wakefield to Selby 31½ miles, with 8 locks. The old locks were 58 to 60 feet long and 14 feet 6 inches to 15 feet wide, but the new ones ran to a width of 18 feet. Vessels drawing 5 feet 6 inches could pass at the date in question, 1831, and improvements were then in execution which would enable vessels of 100 tons burden to navigate these rivers.

In the years 1817 and 1818 a canal from Knottingley to the river Don, with an extension to Doncaster, was talked about; but it was met, as the former project had been, by application successfully made by the Aire and Calder to Parliament for authority to cut a canal from Knottingley to Goole. This was obtained in the year 1820 (June 30), and authorized the cutting of a canal as far as Goole, with two collateral branches. This canal was opened in 1826, in the month of July. It originally began at Knottingley, but was afterwards extended to Ferrybridge, passing thence through Knottingley and running to the south of Snaith, whence its course is parallel to the river Don (or Dutch River) until it reaches the tideway of the Ouse at Goole. The cost as first estimated for this line was £137,000 (\$666,710.50); but a

far greater sum was found necessary. From Ferrybridge to Goole the canal was about $18\frac{1}{2}$ miles; to low-water mark at Goole was a drop of $28\frac{3}{4}$ feet. The width of the canal was 60 feet at top and 40 feet at bottom; depth, 7 feet, and the locks 70 feet long by 19 feet wide.

When this work was commenced Goole was an obscure hamlet containing only a few houses. It began at once to increase and it is at the present time (1890) a port of considerable importance for both foreign and coasting trade. The port is situate 27 miles above Hull, in latitude $53^{\circ} 40'$ north, and longitude $0^{\circ} 52'$ west, and is the most inland port on the eastern coast of England. It has now (1890) a population of about 15,500, and has dock accommodation to the extent (according to the Shipping World Year Book, 1887) of about 23 acres, which is in process of being extended. These docks are connected with the Aire and Calder navigation, and also by sidings with the Lancashire and Yorkshire and Northeastern Railways. Spacious sheds, warehouses, bonding stores, cellarage, and wharfage are provided, as well as a large graving dock of capacity sufficient to accommodate the largest vessel using the port.

A newspaper paragraph recently published gives some shipping details as to one of the lines of steamer trading between London and Goole, and is here annexed:

[The Yorkshire Post, January 28, 1890.]

IMPORTANT PURCHASE OF STEAMSHIP PROPERTY.

Messrs. Fenwick & Co., Abchurch Chambers, Abchurch Lane, London, have purchased the business of William France (limited) as from December 31 last. The latter firm, founded by the late William France, of Leeds, London; and Goole, has for a great number of years run steamers regularly (in connection with the Lancashire and Yorkshire and other railways and the Aire and Calder Navigation's Canal system) between Goole and London. The fleet at the present time consists of the steamers *Northwood* (dead-weight 810 tons), *Bertha* (730), *Fairway* (670), *Paradox* (647), *Vegesack* (560), *Kirkheaton* (550), *Kirkstall* (540), *Contest* (500), and *Edith* (400). Messrs. Fenwick & Co., who will carry on the business under the name of William France & Co. (limited), have adapted the following steamers to carrying on the trade, with the hope that the increase in efficiency and carrying capacity of the fleet will insure a further development of the business: *Lutetia* (1,050), *Belmont* (1,050), *Amy* (1,000), *Nina* (950), *Glannibanta* (950), and *Black Diamond* (800). The staff engaged in carrying on the business will be practically the same as heretofore, under the direct control of Mr. William West, the late company's manager.

I am advised by the Aire and Calder Navigation as follows:

There are other companies trading regularly between Goole and London, and there are also lines of steamers between Goole and Antwerp, Rotterdam, Ghent, Terrensen Hamburg, Bruges, Dunkirk, Calais, Rouen, Ostend, and Boulogne. There are at the present moment about forty steamers engaged in regular service to and from the port, besides steamers and sailing vessels which are not regular liners but which are constantly arriving at Goole with grain, Spanish ore, Jamaica logwood, and other produce, and return usually with coals.

At the time of Mr. Priestley's writing the same cause which had stimulated the undertakers of the Aire and Calder to make the preceding enlargements was again at work; and an act had been obtained June 19, 1828, enabling the undertakers to make further additions and improvements, including a shortening and betterment of the routes between Wakefield and Ferrybridge and between Leeds and Castleford.

The estimate for this work amounted to £462,420 (\$2,250,366.93), allowing £135,350 (\$658,680.78) for dock extension at Goole; and Parliament granted power to borrow the sum of £750,000 (\$3,649,875). (It was expected to shorten the navigation by some miles and to admit 100-ton vessels to Leeds and to Wakefield.)

I am indebted to the Aire and Calder navigation for the annexed

memoranda, as well as for other and valuable information and assistance in the preparation of this report.

In the year 1846 an act was passed under which the Aire and Calder proprietors were empowered to construct a jetty, coal tips, and railway lines connected with their Goole property, and to extend their dock accommodations there, and by further act passed in June, 1889, they received authority to make a number of alterations in the streets, railways, and bridges at Goole with the object of adding an additional dock to provide for the increasing traffic of the port. By the same measure power is given to construct an "incline" or "inclined plane" on the Barnsley Branch Canal, for the transport of boats and other vessels, with hydraulic appliances, in order to expedite the traffic by avoiding a flight of locks at a place called Walton.

From the latest available returns it would appear that the Aire and Calder Trust are the proprietors of the following mileage of navigation:

Aire and Calder navigation (main line) commencing at Goole and terminating at Castleford, where it divides in a westerly direction to Wakefield, and in a northerly direction to Leeds. At Knottingley there is a branch to Selby, $60\frac{1}{2}$ miles.

Sundry lengths of old navigation, $16\frac{1}{2}$ miles.

Barnsley Canal, commencing at Heath Lock, near Wakefield (junction with the above), and terminating at Barnby Basin, 15 miles.

Dewsbury Old Cut, extending from the Calder and Hebble navigation to Savile Town, Dewsbury, 1 mile.

Bradford Canal, commencing at Windhill and terminating at Bradford, joint owners—one moiety—with the Leeds and Liverpool Canal Company, $2\frac{1}{2}$ miles.

The undertakers of the Aire and Calder are also the harbor authority at Goole, and under the Ouse (lower) improvement act of 1884 the conservancy authority of the navigation of the River Ouse, between its junction with the Trent and the railway bridge across the river above Goole. An expenditure of about £250,000 is being incurred in improving this length of the Ouse.

The maximum size of boats using the Aire and Calder navigation main line is given as 120 feet long, 18 feet wide, with a draft of $7\frac{1}{2}$ feet.

On the Barnsley Canal the maximum size is said to be 78 feet 6 inches long, 14 feet 10 inches wide, and 6 feet draft.

THE PORT OF GOOLE.

The largest vessel that has entered the Goole docks is said to be the *Antonios Stathatos*, which in May, 1889, arrived with a cargo of 1,926 tons of grain.

The Engineer, of December 20, 1889, contains an article from which I take the accompanying plan of the port of Goole, and also the principal portion of the context:

RECENT IMPROVEMENTS IN THE PORT OF GOOLE.

The port of Goole is the most central inland port on the east coast of England, being situated about 47 miles from the sea and 20 miles more inland than Hull. Although, perhaps, not so well known as other ports, yet Goole plays an important part in the export and import trade of the country. The prosperity of the port, as compared with the comparative failures of Avonmouth, Portishead, Greenock, and Tilbury to attract trade, shows in a striking manner the advantage of carrying cargoes inland in the same vessels which take or bring them from abroad, and as near to the place of production or manufacture as practicable, instead of attempting to shorten the distance of water transport by carrying the port of delivery nearer to the coast. By

means of the Aire and Calder Canals, Leeds, Wakefield, Barnsley and other large inland towns are provided with an economical and efficient system of water carriage. The manufactures of Yorkshire and Lancashire are transported by water to the heart of the Continent; and food and produce brought back to them from Holland, Germany, France, and Belgium.

Fifty years ago Goole was only an obscure hamlet with a few scattered houses; now it is a flourishing town having 14,000 inhabitants, several large docks, and a shipping trade of 1,200,000 tons a year. The whole of this is due to the enterprise and the management of the "undertakers" of the Aire and Calder navigation, and it shows the immense importance to this country of properly developing its inland water communication. Notwithstanding the competition to which this canal system is exposed by several of the large railway companies, it can yet hold its own and pay better dividends to its owners than those of its competitors.

The Aire and Calder undertaking is one of those inland navigations the proprietors of which were not frightened out of their property by the advent of railways. The management, foreseeing that the days of their monopoly had passed, accepted the inevitable, and, instead of selling their property to their new competitors, the railway companies who had invaded their district, at once set to work to improve and adapt their canals to the altered circumstances. Better terminal and station accommodation was provided at Goole, Leeds, and Wakefield; the locks were enlarged, and the boats improved; steam towing was introduced, and such a progressive course of improvement carried on that this water system of carriage is now able to compete successfully with the railways, not only in rates, but in certainty and regularity in delivery of the goods. The traffic on these canals now amounts to over 2,000,000 tons a year.

The important position which the Aire and Calder Canal system, with its port at Goole, now holds makes it of sufficient interest to trace its history and development during a period extending over nearly 200 years.

In 1820 a third act was obtained for making a new canal from Knottingley to Goole, a distance of 18½ miles, with a descent when in the Ouse of 28½ feet. This canal was laid out by Rennie, and the works carried out by the contractors, Joliffe and Banks. The cut was made 60 feet wide at top, with 40 feet bottom and 7 feet deep, the locks being 72 feet long by 18 feet wide. The parliamentary estimate was £137,000, but this was largely exceeded. Under the powers of this act a ship dock 600 feet by 200 feet, and a barge dock 900 feet by 150 feet, were constructed at Goole. The sill of the lock into the Ouse was laid at sufficient depth to give 15 feet at high water. In 1828, 2 years after the opening of the new port, the undertakers "apprised the public that, so far as custom-house arrangements were concerned, the port of Goole is placed on a footing of equality with London, Dublin, and Liverpool, and of superiority to all others in the United Kingdom." The undertakers in their public announcement also stated "that 2 years had elapsed since the opening of Goole, and 5 months since it was declared a port for foreign trade, and during the time no accident had happened to any of the numerous ships or vessels which had been there; every shipowner manifested the most perfect readiness to repeat his engagements with Goole, and that the trade was daily increasing." They also announced that a steam towing boat called the *Britannia*, of 50-horse power, was provided to facilitate the navigation of the rivers Ouse and Humber. Trade increasing, a fourth act was obtained in 1828 for carrying out further improvements in the canal, and for extending the docks at Goole in accordance with a report made by Telford. The estimated cost of these works was over half a million. Between 1820 and 1828 the locks were again improved, the length being increased to 72 feet, the width to 18 feet, and depth for vessels 7 feet.

Under the power of subsequent acts still further improvements have been made. During the last few years (1860-1880) the locks throughout the main line of navigation have been improved for the third time, and enlarged to a uniform size of 215 feet by 22 feet by 9 feet. Culverts have been placed in the side walls to facilitate the filling and emptying, by means of which the water level can be altered at the rate of 3 feet in a minute. The total length of canals comprised in the Aire and Calder undertaking is as follows:

	Length.	No. of locks.	Total fall.
	Miles.		Ft. in.
Leeds to Goole.....	36	10	65 8
Wakefield Canal.....	12½	4	86 2
Barnsley Canal.....	15	15	106

A new lock and entrance from the Ouse at Goole, on the north side of the Ouse dock, has recently been completed, the dimensions being 500 feet long, 47 feet wide, with a depth on the sill at high water, spring tides, of 24 feet. The connection between

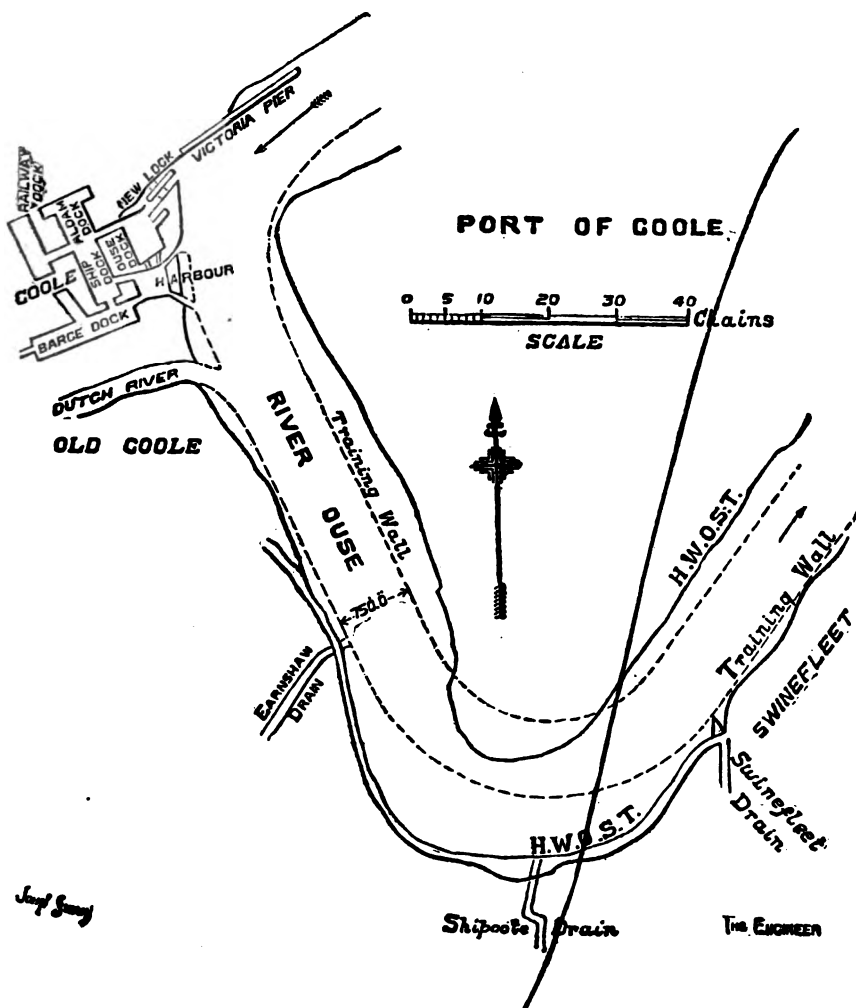
the two sets of docks has been enlarged from 60 feet in width to 224 feet. A new dock, $3\frac{1}{2}$ acres in extent, is now in process of construction to the north of the Aldam dock, and to the west of the parish church. When this is completed there will be altogether eight docks, covering an area of about 30 acres, together with a graving dock, 250 feet long by 57 feet wide. The docks are well provided with warehouses for the storage of grain and other produce. The depth of water at the present time allows of ships drawing from 18 feet to 19 feet to get into the docks at spring tides, and from 14 feet to 15 feet at neaps. The largest ship that has yet entered the docks had a cargo of 2,000 tons, and drew 18 feet. The number of vessels which entered and cleared the port last year was 4,855, of 1,192,124 tons. The principal trade is timber, grain, seed, dye-wood, iron, coals, machinery, manufactured goods, and food. There are regular lines of steamers to Hamburg, Rouen, Ghent, Calais, Antwerp, Rotterdam, Boulogne, Bruges, Dunkirk, and London.

The export of coal forms one of the most important features of the trade of the port, amounting to nearly three-quarters of a million of tons a year. For facilitating the transport and shipping of this coal special appliances have been provided. The coal is brought down the canal from the mines in iron barges, each containing about 35 tons. These barges are made in square compartments, 20 feet long, 16 feet wide, and 7 feet 6 inches deep. Each barge is provided with buffers, and when coupled up is free to move within a certain range, both horizontally and vertically. The boats, to the number of thirty, can be coupled together, and made into a train, the usual number being about twelve to sixteen. A dummy boat with a stem is placed in front, and wire ropes run along each side, and are controlled by two drums, which are self-acting, and are under the charge of the man who is steering. By means of this arrangement the train is easily conducted round the curves. The train is hauled either by a special steamer, which propels the train from behind when it is short, or is attached in front in case of a long train. These compartments on arriving at the docks at Goole are taken to an hydraulic lift, and after being floated over a table, which is sunk to a sufficient depth in the water, and made fast, are raised up, and when at the requisite height tilted over, the contents being sent along a chute into the hold of the vessel. The time occupied by each compartment is usually from a quarter of an hour to twenty minutes. If the ships have self-trimming apparatus, 300 tons an hour can be put into them. In order to cope with the increasing trade and facilitate the dispatch of the steamers, a second hoist has lately been erected by the firm of Sir W. Armstrong & Co. The cost of this hoist amounted to £7,500. The boats and hoists have been designed by Mr. Bartholomew, and constructed under his special supervision. By this system the transport of coals is profitably carried on at the rate of .119d. per ton per mile. It is now intended still further to extend the system, and to place the coal mines which lie away from the canal in direct communication with the ships in the dock. For this purpose an inclined plane is about to be constructed at Stanley provided with rails. The incline will descend into a basin at the side of the canal, with a commencing slope of about 1 in 5 and terminating with a gradient of 1 in 20. The total rise from the canal to the colliery is about 50 feet. A bogie, having its wheels so arranged as to have its top nearly level, will be run down the incline until the compartment barge can be floated on to it. It will then be drawn up and conveyed to the mine, a distance of $1\frac{1}{4}$ miles.

The general traffic of the canal is carried on by men owning their own barges, and by barges and steam tugs belonging to the Undertakers. The tugs carry from 20 to 30 tons of cargo and can haul 12 barges or 8, if fully loaded, and carry from 700 to 800 tons. For the conveyance of manufactured goods, the tugs generally start with their train of barges from the dock at Leeds at the end of the day, and travel during the night. It takes 8 to 10 hours to get from Leeds or Wakefield to Goole, or from 13 to 14 to Hull. Thus goods loaded up in Leeds at the end of the day can be delivered on board the steamers at either Goole or Hull next morning. The tugs run with their train of barges at an average speed, including stoppages, of 4 miles an hour. For boats towed by horses it takes about 15 hours to get from Leeds or Wakefield to Goole, and 4 hours, if towed, from Goole to Hull. They charge for towing boats not belonging to the company, up to 80 tons, is 12s. from Leeds or Wakefield to Goole, the distance being about 32 miles. The cost for horse hire for the same distance is 14s., but the time occupied is double that of towing. The horses are provided by men who make this their business, the canal being divided in regular stages of from 7 to 10 miles.

The river Ouse.—In order to provide for the increasing size of the steamers which now come to Goole, Mr. Bartholomew came to the conclusion some time ago that it was necessary not only to obtain deeper water in the river, but also to effect other improvements in the Ouse between Goole and Trent Falls, where the two rivers unite in the Humber. The depth of water at the shallowest place along this portion of the river used to be only from 2 feet to 3 feet at low water of spring tides. As ordinary spring tides only gave another 14 feet at high water, the pilots had to run the vessels with very little margin under their keels. The river also was very ir-

regular in width, and the sand beds were continually shifting. The most difficult part of the navigation was at Swinefleet, about 2 miles below Goole, where is a very sharp turn, having a radius of 18 chains, and with a tidal current running at the rate of from 4 to 5 knots. By an act obtained in 1884, power was obtained to regulate the width of the channel, and cut off a portion of the bend. The dotted lines on the accompanying plan shows the new course of the river when the training is



completed. The new curve will have a radius of 25½ chains. The improved channel will be trained to a uniform width of about 750 feet. About two-thirds of the new channel have been excavated at the bend, and the training walls over a considerable portion of the remainder have been put in. Already the depth has been increased about 5 feet, and the deepening is still progressing, and no doubt will be more when the training walls are completed and the new cut opened. The training walls are composed of slag brought from Middlesbrough in steam hopper vessels specially constructed for the purpose. There are six of these continually running between the Ouse and the Tees. Two carry 250 tons each, and the other four 450 tons, the total cost of the six being about £50,000. The slag is delivered from the blast furnaces into the hoppers. On arriving in the Ouse, they are moored to piles placed in the lines of the walls, the side doors loosened, and the slag discharged in its place. The height of the walls varies considerably, the greatest depth below low water being 36 feet, and the general average about 12 feet. They are carried up to about neap tide level. The top width varies from 4 feet 6 inches to 6 feet, and the

slope is $1\frac{1}{2}$ to 1. It is estimated that 2,000,000 tons of slag will be required to complete the work. The accumulation of silt and warp behind the walls testifies to the enormous amount of detritus transported by the river. In some places the accretion has amounted to 16 feet in the 2 years that the walls have been in progress. This rapid deposit of material has occasioned a great deal of trouble in keeping open the outlets of the several drainage sluices which discharge into the river, and which have to be extended across the reclaimed portion of the river to the new channel. In one case, near Swinefleet, the Undertakers have been obliged to divert the outfall drain and construct a new sluice, in order to avoid extending it across a wide and deep part of the inclosure. The parliamentary estimate for the river improvement was £252,699, the interest on which is met by a charge of 1 penny a ton on the registered tonnage on all ships going to Goole, and also a penny on the goods conveyed. The whole of the works are being carried out by Mr. Bartholomew for the Undertakers without the aid of a contractor. At Blachtoft, near Trent Falls, about 8 miles below Goole, a capacious mooring and landing stage has been erected for heavy drafted vessels to lie at in case they are late on the tide and not able to get down to sea in one tide. At this stage there is a depth of from 12 feet to 13 feet at low water. Owing to the distance from Goole to the sea, and the short duration of the tide, vessels have to leave the dock at from 1 to 1½ hours before high water, and it is therefore necessary that accommodation should be provided for their safe berthing in case they are not able to reach deep water or are overcome by fog in going either up or down.

TOLLS.

The tolls authorized by the act of 1699 were as follows: From May 1 to October 1, any sum not exceeding 10 shillings a ton, and from October 1 to May 1, any sum not exceeding 16 shillings a ton for the entire distance from Leeds, or from Wakefield to Wesland, or *vice versa*, and so proportionably as to weight and distance.

The second act of Parliament materially reduced the rates of tolls from 10 shillings in summer and 16 shillings in winter per ton on all articles, and fixed them according to the following rates:

Scale of tolls authorized to be taken under the act of 1774.

Description of goods.	Rate.		How charged.
	s.	d.	
Dung or stable manure, coals, cinders, slack, culm, and charcoal, any sum not exceeding.....	per ton	per mile	From Leeds or Wakefield to Selby or Wesland, or <i>vice versa</i> , and so in proportion for any greater or less quantity than a pack, quarter, pecks, or a ton, or for any less distance than the whole.
Pigeon dung and rape dust	do.	do.	
Lime:			
If carried up the rivers or cuts	do.	do.	
If carried down the same	do.	do.	
Pack sheet or bag of wool, pelts, or spetches, not exceeding 312 pounds, including sheet	do.	do.	
For every quarter of wheat, rye, beans, oats, barley, and other grain; malt, rape, mustard, and linseed, of 8 bushels, Winchester measure	do.	do.	
Apples, pears, onions, and potatoes, for every 32 pecks	do.	do.	
Chalk, fuller's earth, pig-iron, kelp, flints, pipe-clay, Calais sand, and other sands (except got in the river), stone, bricks, whiting, rags, and old rope, lead, plaster, alum, slate, old iron, tiles, straw, hay, and British timber	per ton	do.	
Fir, timber, deals, battens, pipe staves, foreign oak, mahogany, and beech logs, per ton	do.	do.	
Flour, copperas, wood, tallow, and ashes	per ton	do.	
Bad butter or grease	do.	do.	
Soap	do.	do.	
Bar iron	do.	do.	
Cheese	do.	do.	
Powder, sugar, currants, prunes, brass and copper, argol or tartar	do.	do.	
Treacle	do.	do.	
Madder	do.	do.	
Cloth bales, and all other goods, wares, and merchandise	do.	do.	

Note from Aire and Calder Navigation, February, 1890: The above are the maximum charges which parliament has authorized to be taken on traffic passing over the navigation. The actual tolls now charged (1890) are, in most cases, less than these.

It may be here remarked, in the scheme of operation of both railway and canal undertakings at this period, that the controlling note was

the deriving of income from the imposition of tolls ; the undertakers of the roadway or of the waterway devoting their energies merely to construction and maintenance, and expecting to receive their profits from independent carriers who might use the way in the course of their business. The increase of traffic, with its attendant economical possibilities, soon brought about a change in the case of the railways to the present system of carriage by the company. The railways still, indeed, permit the use of cars owned by the shipper for a certain class of traffic, but the haulage is done by the company. Canals have been much slower to change ; and while on some canals a large proportion of the traffic is taken by the company acting as carriers, on all of the water routes the occupancy of the way by private carriers is permitted, and on some, perhaps, it is the only method in use.

CANAL TRAFFIC AND ROUTES.

The rates of tonnage first established on the Goole Canal were the same as on the old river navigation.

The lord-mayor and the aldermen of York were appointed in 1462 conservators of the Ouse and other rivers connected therewith. During the five decades, 1828 to 1868, the traffic averaged about 110,000 tons per annum. The navigation in 1872 extended from 8 miles above York to the confluence of the Trent, Ouse, and Humber, 60 miles. There was one lock at Naburn, 70 feet by 22 feet 6 inches fall ; summer height to low water, 9 feet.

As has been already set forth, the Aire and Calder was incorporated in 1699, and subsequent acts of Parliament were procured in 1774, 1820, and 1828. In point of construction and operation this has been regarded up to the present time as the model canal in England.

Up to 1872 there had been expended on this work more than £2,000,000 (\$9,733,000), out of which, borrowed and then due, there remained about £500,000 (\$2,433,250). Interest was paid on this sum before declaring dividends. The amount of share capital and debt is not limited by the acts of incorporation. Proprietors' interests are said to be estimated by the proportion borne to dividend. In 1872 it was stated that the Aire and Calder dividend had ranged up to that time from £40,000 (\$194,660) to £72,000 (\$350,388).

In 1872 reconstruction of the canal for the fourth time was taking place.

The canal was originally made 3 feet 6 inches in depth, and the locks were 60 feet by 15 feet by 3 feet 6 inches. Under the act of 1774 the locks were made 66 feet by 15 feet by 5 feet throughout the system. In 1820 the Goole Canal was constructed with locks 72 feet by 18 feet by 7 feet, and, under the act of 1828, these dimensions were extended to the whole navigation. Since the year 1860 a general improvement had taken place previously to 1883, with locks 215 feet by 22 feet by 9 feet. At that date, 1883, these changes lacked about 3 years' work of being complete as to the routes from Goole to Leeds and from Goole to Wakefield. The canal itself was then 66 feet wide. From 1860 to 1883 £600,000 (\$2,919,900) was said to have been expended in improvements and purchases of mill-power and water rights, etc.; of this amount £100,000 (\$486,650) was spent on the port of Goole, and £32,000 (\$155,728) in purchasing the Bradford Canal.

A summary given in 1883 makes the distances as follows :

Goole to Wakefield, 37 miles ; Goole to Leeds, 36 miles ; Barnsley

branch, 12 miles (acquired in 1871); Bank Dole branch, 11 miles (Bank Dole, 18 miles from Goole to Selby).

Navigation of the river Aire to Rawcliffe and intermediate points not touched by the canal was also in the hands of the Aire and Calder; so that the total length of the undertaking, reckoning canal and river together, was called about 80 miles.

Over the Aire and Calder proper, not including the Barnsley canal, the traffic in 1872 amounted to about 2,000,000 tons, total; equivalent to 42,250,000 tons carried 1 mile. At the same period the rate of the Barnsley was about 250,000 tons per annum, and that of the Calder and Hebble 556,000 tons.

Gross tonnage of Aire and Calder is given in 1838, 1,383,971 tons; 1848, 1,335,783 tons; 1858, 1,098,149 tons; 1868, 1,747,251 tons.

The locks of the Aire and Calder are divided; one length takes two boats and the other length takes one boat, so as to save the water. Three boats of the Leeds and Liverpool Canal will go through the Aire and Calder locks at once.

A large culvert extends alongside the lock with one sluice at the upper end of the lock 7 by 5 feet (the ordinary sluice is 2 or 3 feet square) and at the lower extremity of the lock is another sluice. When that is closed and the lock is empty the upper sluice is raised. It is self-balanced like a throttle valve. Three orifices open into the elongated lock, arranged so as to divide the boats and prevent their knocking together when they are in the lock. To empty the lock the upper sluice is closed, the lower opened and the water drawn into the culvert and discharged at the lower end. This plan is instead of discharging the water at the gate. The sluices are practically self-acting; two turns of the sluice handle raise it, and three turns lower it. The lock is said to be filled and emptied with much more celerity by this plan than in the ordinary way by the gates.

By way of the Aire and Calder there are three routes from Hull and Goole to Liverpool, viz: (1) Through Leeds, by Aire and Calder, Leeds and Liverpool; (2) through Wakefield, by Aire and Calder, Calder and Ribble, Rochdale, Bridgewater, Mersey River; (3) through Wakefield, by Aire and Calder, Calder and Hebble, Sir John Ramsdin's, Huddersfield, Ashton, Rochdale, Bridgewater, Mersey River.

The distances are given as follows:

Route.	Miles.	Route.	Miles.
No. 1.		No. 3.	
Hull to Goole.....	26	Runcorn to Liverpool.....	15
Goole to Leeds.....	36	Total	160
Leeds to Liverpool.....	128		
Total	190		
No. 2.			
Hull to Goole.....	26	Hull to Wakefield.....	63
Goole to Wakefield.....	37	Wakefield to Cooper Bridge.....	13
Wakefield to Sowerby Bridge.....	22	Cooper Bridge to Ashton.....	24
Sowerby Bridge to Manchester.....	33	Ashton to Rochdale Canal at Man-	
Manchester to Runcorn.....	27	chester.....	4½
		Manchester to Liverpool.....	42
		Total	146½

The Aire and Calder, it has been already mentioned, had once a lease of the Calder and Hebble the canal which meets the Aire and Calder at Wakefield. This was for 21 years, and expired about 1886. It was for a gross annual sum to be paid by the lessees, based on rates which proved to be higher than were practicable consistent with keeping the

traffic. The option of purchase which accompanied the lease was framed on the same basis, and hence was not carried out. Some improvements were made on the Calder and Hebble during its occupancy by the Aire and Calder.

The Barnsley branch was purchased by the Aire and Calder in 1871. The fifteen locks on this branch were subsequently lengthened from 66 feet, their length in 1871, to 85 feet, increasing the viable tonnage from 75 tons to 115 tons. This took 2 years and cost about £7,500 (\$36,498.75), called somewhat over £500 (\$2,433.25) per lock. It made the locks of the Barnsley Canal in 1883, 85 by 15 by 6 feet. The Silkstone extension on this branch is now (1890) used merely for water supply, and is without traffic; it is 2 miles in length. It had formerly a large coal traffic on it.

The branch of the Aire and Calder from Bank Dale to Selby, distributed to York, Tadcaster, and Malton, with considerable trade in 1883, which still continues.

The old line through Huddlesey and Snaith to the Ouse was in 1883 nearly disused on account of its circuitousness, and the locks remained at 5 feet, the depth of 1776. The new lines to Goole and to Selby had absorbed the traffic, leaving but a little in coal and timber to the old route. The good navigation through Whitley and Pollington is called the Knottingley and Goole Canal.

In 1883 vessels up to 167 tons burden were going on the line from Goole to Leeds or to Wakefield.

The principal tonnage in 1872 was coal, but they had also a large traffic in grain, stone, timber, dye-woods, and general goods.

There were two recognized systems of traffic on the Aire and Calder, the quick transit or merchandise system and the slow transit or mineral system. The company acted as carriers in addition to being takers of toll, and they do so still. I learn from the company that they convey in the capacity of carriers and by means of fly boats (hailed by steam so far as their own waters are concerned) large quantities of merchandise between the ports of Hull and Goole and Leeds, Bradford, Shipley, Bingley, Keighley, Skipton Colne, Burnley, Accrington, Blackburn, Wigan, Liverpool, Waterfield, Dewsbury, Barnsley, Mirfield, Huddersfield, Brighouse, Halifax, and Sowerby Bridge. Through their agents, they say, they also carry to Rochdale, Todmorden, Littleborough, Heywood, Manchester, and other places. They say the rates of carriage charged by water are less than those of the competing railway companies.

It has been said on high authority that an essential element in successful competition on the part of canals with railways, for merchandise traffic at least, is the undertaking of carriage by the canal companies. Their advantage over individuals in this respect, like that possessed by railways, of organization and consequent reduction of working expenses, is so important an item as to be indispensable. Insecurity in the case of private boats is also indicated as an element of the question. The drayage and collecting of the freight, composed in the case of merchandise, of comparatively small and scattered parcels, make a heavy item too in favor of the principle of carriage as opposed, to simple toll-taking. In the evidence before the parliamentary select committee on canals in 1883 a contrary opinion was advanced; but the weight of the argument would seem to be on the other side, and in favor of canal companies acting as carriers.

The compartment system in use on the Aire and Calder is described in 1872 as recently introduced, for the carriage of minerals. The boats

or compartments are combined in trains like wagons on a railway. Each boat is of 35 tons burden, 16 by 20 by 7 feet deep or nearly square in area. A steamer goes behind to push; the leading boat being shaped with a bow. The steamer couples with the rear boat by a knuckle joint fitted into a hollow stern post free to move vertically or laterally. A wire rope on each side gives steerage to the train. A saving of the crews of the several boats results, the crew of the tug alone conducting the train. The cost was reckoned in 1872 at one-twelfth of a penny (seventeen one-hundredths of a cent) per ton per mile as the whole expense of carriage, *minus* the capital involved in the carrying compartments, but including maintenance of the steam power, *i. e.*, the tug, and the crew in charge of the train. No inconvenience was suffered from wave, which diminished in proportion to the number of boats put on. This was on a canal 66 feet at the surface and 8 feet to 8 feet 6 inches deep. At Goole was a large hydraulic hoist. There the train was broken up, the boats lifted singly and the contents of each tipped in turn into the sea-going vessel. A second powerful hydraulic hoist has since been provided. The cost of haulage at this time was stated to be one-tenth of a penny (two-fifths of a cent) per ton per mile in 60 to 80 ton boats where locks are not closer than 3 miles apart; with a greater distance between locks haulage comes to one-twelfth of a penny (seventeen one-hundredths of a cent) per ton per mile. The distinction here made as regards cost between the *haulage* by ordinary boats and the *carriage* by boat trains does not come out very clearly in the evidence, since the capital involved in the carrying compartments is excluded from the calculation in the last case as being a capital expenditure.

About half the navigation of the Aire and Calder then (1872) was done by steam. Tugs employed were from 50 horse-power to 150 horse-power.

In 1883, Mr. Bartholomew, the manager of the Aire and Calder, in testifying before the select committee on canals, stated that for a large canal like his own, there was no question but that as compared with horse-power, steam haulage was the cheaper. It had succeeded much beyond his expectations on the Aire and Calder. They had tried all kinds of experiments. He began himself in 1852, and had been experimenting ever since. The results achieved were stated by him as follows, for three classes of haulage: (1) Merchandise traffic towed by tugs carrying cargo, also themselves; (2) merchandise traffic towed by tugs not carrying cargo, also themselves; (3) merchandise traffic towed by horses, on the Aire and Calder proper, on the improved system of navigation.

1. Tugs carrying cargo and tugging cargo 4,000,000 ton-miles, one-thirty-fourth of a penny (six one-hundredths of a cent) per ton per mile, allowing 10 per cent. for depreciation of capital and all the repairs.

2. Tugs not carrying cargo, but tugging only, one-seventh of a penny (twenty-nine one-hundredths of a cent) per ton per mile on a ton mileage of 2,250,000, in round figures.

3. Horse haulage, one-fifth of a penny (forty one-hundredths of a cent) per ton per mile on 650,000 ton-miles.

These figures were actual cost in 1882, and in the previous year it was about the same. It had varied very little for some years past.

For merchandise traffic they had a special class of tug constructed by themselves. They made their own engines and boilers, and did all their own repairs, in their own workshops. With a larger mileage it could be done for less. The steam merchandise traffic speed is called $4\frac{1}{2}$ to 6

miles an hour. For the carriage of minerals the cost for 5,500,000 ton miles was one hundred and nineteen one-hundredths of a penny (twenty four one-hundredths of a cent) per ton per mile for mineral traffic by the through trains already described, including cost of taking back the empties. By ordinary boat, simply taking cargo and not returning empties, it cost one hundred and fifteen one-thousandths of a penny per ton per mile.

In 1883 the boat train consisted of 40 tow compartments, up to 30 in number, 22 not being unusual, though more generally 11 or 12 made the train. With so many as 30 the tug precedes the train; as many as 11 can be pushed. The locks of 215 feet take tug, tender, and 11 compartments; with more boats the train would have to be broken. The compartments loaded draw from 6 feet to 6 feet 3 inches. Nine hundred tons has been loaded on one train; 700 tons is called a very convenient train. The hydraulic hoist at Goole has a cage like a colliery cage for raising coals and within the cage a cradle, in which the boat is secured in order to be raised and tip its contents into a shoot which delivers into the vessel. In lowering back the cage with the empty boat the water in one of the cylinders is forced back into the accumulator. There are two lifting cylinders, and the weight of the descending cage and boat forces half the water back again into the accumulator. The advantage of pushing is said to be in the steering. The steamer has a water tank forward for regulating her head as to draft, depressed for a loaded train and raised for a light one. The steering rope passes around a pulley direct to a cylinder, one on each side of the tug, and is threaded through guides attached to each compartment boat. Trains loaded and of not more than 10 boats can be steered by pushing in any weather. The train can go to any curve by the two convex surfaces and is at the same time free to rise or fall vertically. The compartments are held together as a train by means of wire ropes in a state of tension. Each compartment is provided with buffers, tending to bring the boats back into place when they are driven aside either by wind or water. The wire rope from the steering gear of the steamer passes alongside the boats and holds the train together while guiding it as it pushes it forward. The compartments had also been altered to adapt them to the carriage of merchandise. Those for merchandise are decked over with a hatchway and tarpaulin covers. Such can take either merchandise or minerals. Mr. Bartholomew claims this to be the most economical system of carriage, though doubtful whether it is so for haulage.

He gives for ordinary boats to carry 750 tons 12 boats for merchandise traffic; 2 men to a boat makes 24 men, and 4 for the tug, a total crew of 28; while a steam train requires only the crew of the tug, *i. e.*, 4 men, so that 24 men are saved.

The same traffic which on the Aire and Calder system of tugs carrying cargo costs one thirty-fourth of a penny per ton per mile, on the Leeds and Liverpool system would cost three-tenths of a penny, or in the proportion of six one-hundredths of a cent to thirty one-hundredths. Mr. Bartholomew thinks ordinary canals should be improved before introducing such steam haulage upon them as the Aire and Calder uses. The cost of one thirty-fourth of a penny per ton per mile on merchandise traffic, tug carrying cargo as well as tugging the other boats at the speed of $4\frac{1}{2}$ to 6 miles per hour, is the actual cost to the company of hauling the loaded boats, including the cost of the tug, but not including the cost of the boats, except for the haulage of them, corresponding to engine power on a railway. Little through traffic by water goes from Goole or Hull to Liverpool; not more than 2,000 or 3,000 tons

per annum. The great traffic is the intermediate. At Leeds goods are transshipped from Aire and Calder into Leeds and Liverpool boats. From Goole to Liverpool the Leeds and Liverpool boats might be employed; but they would be too light for the tideway between Hull and Goole. Of local traffic something like 300,000 tons is exchanged between the Aire and Calder and the Leeds and Liverpool; that is to say, it goes from one to the other line; actual transshipment would not amount to above 10,000 tons a year.

Coal and traffic originating below Leeds goes over the Leeds and Liverpool system till it meets the Lancashire Coal at about Skipton, some 30 miles from Leeds. Road and paving materials come from points on the Leeds and Liverpool Canal to Leeds and are there loaded into sloops for London.

There was considerable traffic from the Aire and Calder over the Rochdale by way of the Calder and Ribble in 1883. The locks of the Calder and Ribble were 63 feet by 14 feet 6 inches by 5 feet, taking a vessel 57 feet 8 inches long, 14 feet 2 inches wide and 5 feet draft, 50 tons burden. On the Rochdale Canal locks are 81 feet long, admitting the same width of vessel (14 feet 2 inches), but 70 feet long, and with a less draft of water viz, 3 feet 10 inches, giving 60 tons burden by reason of the longer lock despite the shallower depth. The Rochdale had been in the hands of railway companies, the lease expiring about 1875. The traffic from east to west is generally carried in one bottom. The Aire and Calder, however, does not carry as a carrier beyond Sowerby. From that point private carriers do the work, and the goods are generally transshipped at Sowerby. Sometimes on small boats it goes through. The long boats are cheaper. Grain, for example, is brought from the west in long boats to Sowerby, and there transferred to the short boats, while the short boats load with stone to the west and naturally load back. Stone traffic, like flags, will not pay for transshipment; it commands too low a freight. Grain, on the other hand, will allow transshipment and it is more convenient to do so.

There was a through toll charged by the canal companies which would be included in any rate agreed upon with a private carrier.

The through carrier received freight at Goole; the Aire and Calder, if the carrier had no boats going through, would take it for him as far as Sowerby over their own canal and the Calder and Ribble to the Rochdale at Sowerby. The through carrier was the responsible party. He might carry through himself, or only partly so, as described. A large portion of the goods going from Goole to Manchester direct were taken through by the carrier, but for broken parcels, that is to say, 10 and 12 ton loads, the Aire and Calder would take the goods for him and deliver to him at Sowerby, whence he would take them forward. The carrier in such cases received the total freight and paid the Aire and Calder for their share of the work. He made a contract with the shipper from Goole to the point of destination and a subcontract with the Aire and Calder to Sowerby. At Sowerby the Aire and Calder as carriers were bound to deliver on the quay; but instead of this they delivered it to the boat, and the through carrier's crew received it on the boat without its going on the quay. Of the through rate charged by the carrier the Aire and Calder got a mileage proportion, deducting in the first place the cartage.

Sir John Ramsden's canal (4 miles long) had the same locks as the Calder and Hebble. From Huddersfield towards Manchester the Huddersfield Canal had locks only 7 feet wide. Very little traffic was exchanged with the Aire and Calder on that system except to Hudders-

field. A considerable traffic then went to Huddersfield, but not beyond. This is attributed to the narrow gauge and railway control. The Huddersfield Canal was said to not have the same local traffic as the Rochdale and not to go through a number of towns as the Rochdale does. The Huddersfield and the Ramsden Canals are both absolutely incorporated with the London and Northwestern Railway system, a line of which runs from Leeds via Huddersfield to Manchester and Liverpool, practically coincident with the canal. As regards the Aire and Calder, railway competition comprehends the following roads:

The Northeastern, from Hull to Leeds, by way of Selby.

The Lancashire and Yorkshire receives Hull traffic at Goole Junction and also runs through to Goole.

The Manchester, Sheffield and Lincolnshire goes to Grimsby, which is a port with continental trade, but not a point in which the Aire and Calder has much interest. The Don Navigation, under control of the Manchester, Sheffield and Lincolnshire Railway Company, competes with Aire and Calder for the South York's coal field.*

The London and Northwestern from Liverpool and Manchester, the Great Northern from London, and the Midland from London, with their branch lines, penetrate the West Riding coal fields, giving outlet and inlet to the Leeds district, and naturally competing to a greater or less extent with any other lines of communication and supply. The railway competition effects local traffic as well as through traffic.

The Aire and Calder is partly dwarf walled, and partly has pitched slopes. The latter are said to be well adapted to small canals with little local traffic; but for a large water way with full traffic dwarf or other walls are needed. Dwarf walls are commended for continuous walling in preference to full walls. The latter are fit for a distributing canal like the Birmingham; but for ordinary navigation the dwarf wall is better. One advantage is the resulting slope which lets the boat scrub against it without harm in the case of a side wind. Cost of walling as stated by Mr. Bartholomew varies for dwarf walls from 15s. (\$3.65) to 30s. (\$7.30) per yard run. They may be of soft or hard stone, of concrete, or of brick.

Another witness before the committee in 1883, Mr. E. J. Lloyd, engineer and general manager of the Warwick Canals, speaks to the benefit of dwarf walls, which he describes as reaching to a distance of 2 feet or 2 feet 6 inches below the water line, and as used almost exclusively in lieu of complete walls. They are said to be employed to a considerable extent in the canal development between Hull and Liverpool, and to give great advantage for steam haulage. Their use goes far towards avoiding the necessity for cleaning out the bed of the canal; presenting a marked contrast to the régime of the old canal system, where constant silting and tendency to fill up the water way existed, only to be remedied by unceasing attention and labor.

The cost of walling on Mr. Lloyd's own canal at contract price is given as 13s. 6d. (\$3.28) per yard forward, dwarf or one side; or £1 7s. (\$6.57) for both sides; walls put in 4 feet deep of brick; 18 inches thick half way down and the remainder 22½ inches thick (2½ bricks of 9-inch length); canal 5 feet deep. Mr. Lloyd reckons 20 years saving to equal cost of wall; that the dwarf wall is more economical by almost half, and serves its purpose altogether; is sufficient and decidedly the best.

* This latter navigation is, by an act passed in 1889, proposed to be transferred from the railway company to an independent proprietary.

Mr. Abernethy in 1883 says in large canals no more detriment occurs to walls from steam haulage than from that by horses. At speed of 4 to 4½ miles per hour wash would do no injury at all to canal.

In the year 1761 the Duke of Bridgewater's canal was opened from his coal mines at Worsley to Manchester, having been executed under authority of an act of Parliament passed in 1759, in furtherance of a previous authority from Parliament in the year 1737, warranting the making navigable of the Worsley Brook from Worsley Mill to the river Irwell, which last named act, however, had been until then neglected.

The success of this undertaking gave a spur to a scheme which had been long in contemplation for a navigation between the North and the Irish Seas, by way of the rivers Aire and Ribble. The latter river, the Ribble, it may be remembered, is the one with which the West Calder, starting from near the source of the Calder River, unites and runs into the Irish Sea. The course indicated, therefore, with reference to the Pennine Hills, was that of the natural watershed, namely, conforming generally to the valleys of the two rivers mentioned above, and crossing the Pennine range in the neighborhood of their common source. As carried out the route did not follow the Ribble line except approximately.

Upon the establishment of the Bridgewater Canal Mr. Longbotham, a native of Halifax, after an investigation of the Bridgewater works, conceived the project for a similar canal between Leeds and Liverpool. With this in view he made an actual survey of the route, with a plan and estimate which were shown at meetings held among landowners of the country who were interested in the undertaking. In order to more fully ascertain the practicability of the route a resurvey of the line laid down by Mr. Longbotham was obtained from Mr. Brindley, the engineer of the Bridgewater, assisted by Mr. Whitworth. The report of the resurvey was made to two meetings, held respectively at Bradford and at Liverpool in December, 1768, with the statement that the scheme was feasible and might be carried out for the sum of £259,777 (\$1,264,224.77), for which details were given. According to this estimate the canal was to be 108¾ miles long, 42 feet wide at the top, 27 feet at the bottom, and 5 feet deep. It was the most extensive canal undertaking at the time in Great Britain.

The act under which the Leeds and Liverpool Canal was made received the royal assent May 19, 1770. The Douglas River navigation, from the river Ribble to Wigan, had been authorized in the year 1720, and this navigation was purchased in large and controlling part by the Leeds and Liverpool Canal in 1772. In 1780 the entire Douglas River property passed into possession of the canal company, which extended the canal and abandoned the river navigation, except for a short distance in the tideway. In 1783 the navigation was incorporated with the canal. It was estimated, including all the improvements, to have cost about £74,000 (\$360,121).

The route of the Leeds and Liverpool Canal is from Leeds Bridge, where it joins the Aire and Calder, 27 chains in the river Aire to the first lock on the canal where the warehouses, docks, and basins are situated. Thence it takes a northwesterly course by Kirkstall Abbey and Shipley, where (Bradford 3 miles distant) the Bradford Canal branches off, 155 feet 7 inches above the surface of the Aire at the initial lock at Leeds. At New Mill the canal crosses the Aire by an aqueduct and runs northwesterly to Bingley, where an ascent by locks of 88 feet 8 inches takes place to an 18-mile level without a further lock. At this time (1830) the great lock at Bingley consisted of five lifts in one range

of masonry; a very uneconomical arrangement, requiring five locks full of water to pass one vessel from the lower to the higher level. From Bingley Great Lock the canal goes near Keighley and on to Skipton, where it attains an elevation of $272\frac{1}{2}$ feet above the Aire at Leeds. Above Gargrave it again crosses the Aire by an aqueduct. It then bends southwesterly and reaches the summit lock at Greenberfield, an elevation of 411 feet 4 inches above the Aire at Leeds, and a distance of 41 miles. At Foulridge begins the great tunnel, 18 feet high, 17 feet wide, and 1,640 yards long. The water in the tunnel, at its greatest depression, is 60 feet below the surface of the upper ground. Two reservoirs near the tunnel, covering 104 acres of land, were made for the supply of water to the canal, of which they would contain 1,200,000 cubic yards.

Near Barrowford the canal locks down 70 feet, an aqueduct takes it across Colne Water, whence it goes to Burnley; round three sides of which it passes, and where is an embankment for 1,256 yards, about 60 feet high, with aqueducts over the rivers Brown and Calder and the highway. Another tunnel 559 yards in length is near Gannah. Thence the canal goes by Hapto to Church Valley, across the river Hepburn by an aqueduct, past Rushton to the town of Blackburn, now celebrated for its cotton mills, and near which the canal level drops by six locks a fall of 54 feet 3 inches. Thence over Derwent Water by one aqueduct and Raddlesworth Water by another, it goes near Chorley. At Cophurst Valley the canal locks down 64 feet 6 inches, by seven locks, into the head level of the Lancaster Canal at Johnson's Hillock. Here the Lancaster canal intervenes for 11 miles on one level, when the Leeds and Liverpool begins again near Kirklees, at the head of a range of twenty-three locks, which bring the level down 214 feet 6 inches to the basin at Wigan. From Wigan to Newburgh constitutes the Upper Douglas navigation, 7 miles with a fall to Newburgh of 30 feet.

From Newburgh, $28\frac{1}{2}$ miles on the same level, passing Burscough, Halsall, Lidiata, over the Alt River, and by Bootle, gets to the Leeds and Liverpool canal basin at the North Lady's Walk, in Liverpool. The distance from Leeds Bridge to the Liverpool Basin is 127 miles 13 chains, with a lockage of 844 feet $7\frac{1}{2}$ inches, *i. e.*, from Leeds to the summit a rise of 411 feet $4\frac{1}{2}$ inches, and from the summit to the basin at Liverpool a fall of 433 feet 3 inches, showing the basin at Liverpool 21 feet $10\frac{1}{2}$ inches below the level of the Aire at Leeds; the basin at Liverpool being 56 feet above low-water mark in the river Mersey.

Three miles from Newburgh the Lower Douglas navigation joins the Leeds and Liverpool Canal. The Douglas navigation locks into the tideway at the tail of Tarleton Cut, whence the Ribble is $2\frac{1}{2}$ miles and the custom-house at Preston $6\frac{1}{2}$ miles farther.

Under the act incorporating the Leeds and Liverpool company power was given to raise £260,000 (\$1,265,290) in £100 (\$486.65) shares, with authority to increase by £60,000 (\$291,990) if the first was found insufficient. Proprietors were to be allowed 5 per cent. interest during construction.

The estimate for the canal was made by Mr. Brindley and amounted to only £259,777 (\$1,264,224.77), as already stated. He being unable to superintend the work, it was given to Mr. Longbotham, who within 7 years (from 1770) completed the canal from Leeds to Holmbridge, near Gargrave, $33\frac{1}{2}$ miles, at a cost of £176,000 (\$851,637.50) and from Liverpool to Newburgh, 28 miles, at a cost of £125,000 (\$608,312.50). The Liverpool end was opened in 1775 and the Leeds end in 1777. These works and the purchase of the Douglas navigation seem to have con-

sumed all the money authorized to be raised. Further legislation was obtained in 1790, under which a further credit of £200,000 (\$973,300) was authorized on mortgage of the tolls and preferring the interest. In this year (1790), Mr. Whitworth, being the engineer, resumed construction at Holmbridge. A resurvey showed an estimate of nearly £170,000 (\$827,305) as needed to complete the line. He also recommended some improvements, the most important being a tunnel at the summit level near Foulridge, by which a head level of above 6 miles was substituted for one of 1 mile. This part he also made 2 feet deeper to serve as a reservoir in dry seasons. The work from Holmbridge to Wanlass Banks, 14 miles, with 208 feet of lockage, cost £210,000 (\$1,021,965) including £40,000 (\$194,660) for the tunnel at Foulridge.

In order to accommodate the increasing manufactures of Lancashire the proprietors abandoned the idea of the shortest line and had a survey made through the coal and mill districts. In 1794, accordingly, the company applied to Parliament for new powers and obtained another act. They were authorized to borrow or raise among themselves or by admission of new subscribers the further sum of £280,000 (\$1,362,620), £101,394 (\$493,433.90) of which was to go to repaying that sum borrowed under the preceding act and the remainder to finishing the canal.

In May, 1796, the canal was opened to Burnley, 8 miles farther, with a lockage of 70 feet. Again in 1801 9 miles 37 chains were added, making in the 17½ miles from Foulridge to Henfield the most expensive as well as the most difficult work on the route. This stretch cost £120,000 (\$583,960), including £40,000 (\$194,660) for Foulridge tunnel, £9,000 (\$43,798.50) for reservoirs there, £22,000 (\$107,063) for embankment at Burnley, and £10,000 (\$48,665) for another tunnel near Burnley. The construction proceeded slowly, but in 1810 another stretch of 8 miles was opened from Henfield to Blackburn. This last and the remainder of the canal from Blackburn to Wigan was done under direction of Mr. Y. Fletcher. The canal was finally completed and opened for through trade from Leeds to Liverpool in October, 1816.

It may be observed that the company left their own line at Cophurst and locked down 60 feet 6 inches into the head level of the Lancaster Canal, which consequently, for 11 miles, from Cophurst to Kirkcless, forms part of the Leeds and Liverpool. An agreement to this effect was made and confirmed by Parliament in 1819. The Leeds and Liverpool Canal was 46 years in building, and up to 1830 had cost £1,200,000 (\$5,839,800), £400,000 (\$1,946,600) and more of which was borrowed.

TOLLS.

The tolls were estimated on the original scheme drawn up by Mr. Brindley, but had not been increased. The act of 1770 fixed them as follows:

Tonnage rates.

	d.
Clay, brick, or stones	per ton per mile.. ½
Coal or lime	do..... 1
Timber, goods, wares, merchandise, or other commodities.....	do..... 1½
Soap, ashes, salt, salt scrow, foul salt, and grey salt, pigeon dung, rape or cole seed; dust, rags, or tanner's bark to be used for manuring lands of any person whose lands shall be cut through, lying in the township through which the canal passes	per ton per mile.. ½

All small rubbish, waste stones from quarries, gravel, and sand employed for repairing roads, not being turnpike, if not carried more than 5 miles; also all dung, soil, marl, ashes of coal, and turf for the improvement of lands belonging to persons through whose lands the canal

passes, but not to pass any lock unless the water flows over the gauge, paddle, or niche of such lock, are exempt from toll.

Fifty feet of round or 40 feet of square oak, ash, or elm timber, or 50 feet of fir or deal, oak, poplar, and other timber wood to be deemed 1 ton weight; and the ton of coals and limestone to be twenty-two hundred weight of 112 pounds each.

Vessels carrying less than 20 tons are not to pass locks without consent, unless tonnage be paid for 20 tons.

Lords of manors and landowners had power to erect wharves, etc., upon their lands, but if not exercised within 12 months after notice given by company, then the company might erect them.

Wharfage rates.

	<i>d.</i>
Coals, stone, or brick, not longer than 6 days.....	per ton.. 12
Goods or merchandise, not longer than 6 days.....	do..... 3

No charge whatever if the articles do not lie longer than 6 hours. Fractions of a mile to be reckoned as a mile, fractions of a ton as the quarters of a ton, and of a quarter as a quarter. Every vessel passing the Leed's Lock to pay the tonnage of 8 miles.

When the canal shall communicate with the Douglas Navigation at or near the warehouses in Wigan, the coals, stones, timber, goods, wares, and merchandise passing upon any part of it shall be charged no more than if the same had been carried the like distance on the Leeds and Liverpool Canal.

The act for the branch to Leigh repealed the clause imposing charge on passing locks for burthen of 20 tons and enacted that empty boats should pay 5 shillings at the first lock only and an extra 5 shillings for passing through or returning out of the summit level.

The act for the branch to Leigh was obtained after finishing their main line in 1816, when the company turned towards Manchester; and having gotten authority from Parliament for a line from near Wigan, communicating at Leigh with the Bridgewater Canal leading to Manchester, the work was undertaken and in 1821 was completed. It was nearly 7 miles in length, with a lockage down of 15 feet 2 inches by 2 locks. The cost of this branch was above £50,000 (\$243,325). Stone for paving and building, limestone for roads and for burning into lime, and important coal supplies are among the products whose distribution is facilitated by the canal. In addition it greatly helps the interchange of commodities between the manufacturing districts of Lancashire and Yorkshire; and finally it affords communication by water between Hull, Leeds, and Liverpool.

LEEDS AND LIVERPOOL CANAL.

The merchandise traffic of the Leeds and Liverpool Canal was leased to certain railway companies for 21 years expiring in 1874. On certain percentages of liability the railways paid so much a year for the merchandise traffic, leaving the mineral traffic and the maintenance of the canal with the canal company. Since the termination of the lease, according to Mr. Bartholomew's evidence in 1883, from which I derive these facts, through rates for the Aire and Calder and the Leeds and Liverpool had been arranged. A reasonable and fair increase of traffic, more than was due to the general increase of the traffic of the country, had resulted.

The Leeds and Liverpool Company themselves had become carriers since the lease expired, and had carried merchandise traffic themselves largely.

During the tenure by the railway companies the toll for merchandise was very heavy; $1\frac{1}{2}d.$ (3 cents) per ton per mile maximum was actually charged, making a through toll of 16s. (\$3.89) from Liverpool to Leeds, 128 miles. The railway rate for the same article was 15s. (\$3.65); while the canal toll upon coal which was under control of the canal company was one-third of a penny (\$0.0067) per ton per mile. Now (1883) the merchandise toll was reduced to three-fourths of a penny (a cent and a half) for the same service, a reduction of 50 per cent.; and there was a fair amount of traffic and the canal paid 21 per cent. dividend. The railway rates also underwent a reduction.

As to dividend, Mr. Powell, in 1883, says that the figures of 10 per cent. and 20 per cent. for the Leeds and Liverpool are illusory, and that the £100 share (\$486.65) is only a book entry; that in its construction and maintenance costs of ordinary repairs and capital were all mixed up together in respect of expenditure, and that the sum which stands as a £100 share really represents a very much larger capital, probably several hundred pounds. It may be noted in this connection that two shares of the company were sold at Bradford in December, 1889, at £430 (\$2,092.60) per share.

Six months before the expiration of the railway lease referred to above the Aire and Calder Company made an arrangement for a reduction of rates, under which the Leeds and Liverpool were obliged to recoup the railway interest for their loss thereby.

The tonnage of the Leeds and Liverpool in 1874 is given as 1,779,208, the details, as stated, making a slightly larger total, as follows:

Coal	tons..	1, 149, 842
Bricks, etc	do...	293, 320
Manure	do...	58, 317
General merchandise	do...	321, 729
Total		1, 823, 208

In 1880 the same authority gives 2,215,686 tons with details here:

Coal	tons..	1, 301, 105
Bricks, etc	do...	325, 136
Manure	do...	127, 986
General merchandise	do...	461, 459
Total		2, 215, 686

The gross tonnage was 1,436,160 tons in 1828; 2,601,577 tons in 1848; 2,141,151 tons in 1868; thus seeming to have reached its highest at or about a time coincident with the great railway development of the later forties.

The lockage of the canal in 1883 comprised 91 locks; 42 from Leeds to the summit; 49 thence to Liverpool. At one point, Wigan, there were said to be 23 locks in 3 miles.

The dimensions are given variously within certain limits; the most trustworthy figures would seem to be about as follows for the locks in 1883:

	Length.	Width.	Depth.
Yorkshire side:			
Summer	<i>Fect.</i>	<i>Ft. In.</i>	<i>Ft. In.</i>
Winter	} 66	15 2	{ 3 8
Winter			{ 3 10
Lancashire side:			
Summer	} 76	15 2	{ 3 8
Winter			{ 3 10

A recent newspaper report makes an estimate of the amount expended on the Leeds and Liverpool Canal from the commencement of the undertaking to the present date, that is to say, from 1770 to 1889, and reckons the total sum at £1,500,000 (\$7,299,750), of which by far the greater part is deemed to have been contributed from savings out of revenue.

Under the scheme of reorganization which was adopted at the half-yearly meeting of the company held in Liverpool the 20th September last, it is reported to be proposed to extinguish the old shares of the company and to apply to Parliament for power to create £1,500,000 of ordinary stock for the present shareholders, and a further sum of £600,000, either ordinary or preference stock for new works. Against that sum of £2,100,000 (\$10,219,650) the proposition reported is to take powers to issue debenture stock in the usual proportion of one-third, namely, £700,000 (\$3,406,550).

The scheme is said to include the deepening of 103 miles of the canal to a depth of 5 feet 6 inches, and the making all the locks 72 feet in length. This length of canal includes 80 miles direct line from Leeds to Liverpool and 23 miles of branches. It is estimated that this improvement will admit boats carrying cargo of a dead weight of 80 tons, being nearly double the present limit. The total estimated cost of these works is set at £750,000 (\$3,649,875). Other incidents, by way of reservoirs, boat construction, etc., are estimated at £83,000 additional, making a total sum of £833,000 (\$4,053,794.50). The water supply of the canal is said to have been below the requirements now for many years, seriously impeding the traffic in time of drought, and at times even stopping it in the upper and middle reaches. Power to construct additional reservoirs is looked to for the remedy of this trouble.*

WHARFE RIVER NAVIGATION.

For illustration of some of the preliminary steps taken towards initiating another kind of water transportation, namely, what is known in England as a navigation, the following advertisement is annexed, together with an extract from the engineer's report upon the project.

In the course of his observations the engineer says :

The river consists of a series of deep pools and shoals, which latter act as natural weirs, and maintain the depth of water in the pools. I am of opinion that no satisfactory improvement could be carried out by dredging alone, as the effect would be to lower the river bed, thereby increasing the depth at high water; but the present low-water depth would be diminished, and the pools in which vessels are now able to ride throughout the tide be to a certain extent drained. The navigation would thus become almost entirely tidal, which condition would be unsatisfactory owing to the short duration of the tidal flow, it being only about 2 hours at Wharfe Mouth. To effect a permanent navigable depth I would recommend that a weir be constructed at a point a little below the village of Uileskelf, by means of which the present summer level above the weir could be raised 2 feet, or say 1 foot above the level of a spring tide at Tadcaster. This would not interfere with the efficient drainage of the land, and the only dredging necessary between the weir and Tadcaster would be the removal of the tops of the shoals. Below the weir the depth would have to be main-

* Since the foregoing was written, the bill of the Leeds and Liverpool Canal has been withdrawn from Parliament, and the scheme accordingly seems for the present in abeyance. The details given will perhaps be of interest as indicating something of the form followed under such circumstances. Here, as elsewhere in the compiling of this report, I have been forced to depend largely, if not altogether, upon what Mr. Conder, in his evidence, describes as "literary sources," and the absence of technical accuracy in these, or many of them, has required the aid of something more nearly resembling hypothesis than is altogether desirable. This defect of trustworthy and definite information, which is referred to in another connection in this report, is universally acknowledged and regretted.

tained by means of dredging at a moderate cost. It will be obvious that the retaining of the water at a higher level than at present will be a great improvement to the navigation; it will also be of advantage to the riparian owners, inasmuch as a supply of clean water for cattle or irrigation purposes would be easier procured owing to the raised level. There could be no increased liability of flooding as the weir would be so constructed that it might be lowered level with the river bed in a few minutes; and seeing that the shoals above the weir would be removed, and the bed of the river below lowered, the flood water would undoubtedly get away quicker than at present, there being a more commodious channel for its passage. The salmon fishery would not be affected, as the weir would be open at high water twice a day, as well as for the passage of boats at intermediate times. The greatest leap for a salmon would be only 4 feet, even were the weir never opened. During freshets, when the majority of salmon go up the river, the weir would be entirely lowered, and kept down throughout the duration of the freshets. Should the fishery board, notwithstanding the latter facts, consider that the fish would be impeded, a salmon pass could be constructed to their satisfaction. I have carefully considered the existing privileges in connection with the head of water at the Soke mill. This will not be interfered with, as although the water level in the vicinity of the weir would be raised 2 feet, yet the natural inclination of the water surface is such that it would not even then be within 3 inches of the level at the mill, but owing to the dredging operations the level at the mill would be lowered to this extent, and thus the head of water really increased. There would be an abundant supply of water for lockage purposes. The basin of the Wharfe extends over about 470 square miles, which would give a supply say during the driest weather of 6,000,000 cubic feet per day, whereas the quantity used in passing one vessel would be about 4,000 cubic feet. My estimate for the whole of the necessary work is £3,666. The time occupied in constructing the weir would be about 6 months. After its completion the river would be sufficiently improved to warrant the company in charging dues, although the dredging might not be finished.

The notice of intended application to Parliament is as follows:

WHARFE RIVER NAVIGATION.

[In Parliament—Session 1890.]

(Incorporation of Company and vesting in them Waterway of River Wharfe for Navigation purposes—Power to Deepen, Alter, and Render Navigable the River Wharfe from Tadcaster to its confluence with the River Ouse—Tramways in Tadcaster—Street Widening—Subsidiary Works to Navigation—Compulsory Purchase of Land—Tolls, Dues, and Charges—Company may act as Carriers—By-laws, etc.—Agreement with Ouse Navigation Trustees, etc.—Incorporation and amendment of Acts.)

Notice is hereby given that application is intended to be made to Parliament in the ensuing session for an act to incorporate a company (hereinafter called the company), and to vest in the company for navigation purposes the waterway of the River Wharfe from the Soke Mill at Tadcaster to its junction with or outfall into the river Ouse, and for such purposes to confer upon the company all necessary powers for facilitating and expediting the passage of barges, boats, and other crafts between the Ouse navigation and the town of Tadcaster.

The intended act will authorize the company to make and maintain the following river improvements, tramways, and other works, and exercise the following powers, or some of them; that is to say—

(1) To dredge, scour, deepen, and render navigable the bed and channel, or waterway, of the River Wharfe, and to straighten, repair, improve, and maintain the banks thereof from Soke Mill aforesaid to the River Ouse, which works, repairs, and improvements will be situate in the parishes, townships, and places of Tadcaster, Tadcaster East, Tadcaster West, Oxton, Bolton, Percy, Kirkby, Kirkby Wharfe, Grimston, Ulleskelf, Ryther, Bolton, Appleton, Roebuck, Nun-Appleton, Acaster-Selby, Stillingfleet, and Cawood, or some of them in the West Riding of the county of York.

(2) To construct and maintain a weir and lock in and across the River Wharfe at or near the ferry at the southern end of the village of Ulleskelf, to be situated in the bed and on the banks of the river, and on adjoining land in the township of Ulleskelf, and parish of Kirkby Wharfe, belonging to Charles Shann, esq., and in the occupation of Joseph Bean, and in the township of Bolton Percy, in the parish of Bolton, belonging to Sir Fredk. George Milner, Bart., and in the occupation of John Upton.

(3) To form, lay down, maintain, and use with all proper rail plates and conveniences connected therewith the tramways hereinafter described or one of them in the township of Tadcaster West in the parish of Tadcaster, that is to say:

Tramway No. 1.—Commencing at a point on the west bank of the River Wharfe at or near the cottage and premises known as “the old Crane wharf,” thence proceeding in a westerly direction along Crane House lane to a point opposite the gas works, and thence in a northerly direction along Centre lane and terminating at the end of the last-mentioned lane at a point where the same adjoins the High street.

Tramway No. 2.—Commencing by a junction with tramway No. 1, before described, at a point in Crane House lane 14 yards or thereabouts, measured in an easterly direction from the point of intersection of the center lines of New street and Crane House lane, thence proceeding in a westerly direction along Crane House lane to New street, and thence northward along New street and terminating at or opposite to the Old Brewery on the east side of New street.

(4) To widen Crane House lane on the south side thereof, such widening to commence at or near the southern end of New street aforesaid and extend eastward thereof for a distance of 7 chains or thereabouts.

At the following places it is proposed to lay the tramways so that for a distance of 30 feet or upwards a less space than 9 feet 6 inches will intervene between the outside of the footpath on the side of the street or road hereinafter mentioned and the nearest rail of the tramway; that is to say—

Tramway No. 1.—In Crane House lane, on the east side, from the southern end of New street to the termination of the tramway.

Tramway No. 2.—For a distance of 1 chain or thereabouts on the northeast side from the commencement of the tramway to the end of the curve into New street.

(5) To empower the company, when by reason of the execution of the work affecting the surface or soil of any street, road, or thoroughfare it is necessary to remove or discontinue the use of a tramway or any part thereof, to make in the same or any adjacent street, road, or thoroughfare, and to maintain so long as occasion may require, a temporary tramway in lieu of the tramway or part of a tramway so removed or discontinued to be used or intended so to be.

(6) To empower the company on the one hand, and the body or persons having the control or management of the streets or roads along which tramways are intended to be laid on the other hand, to enter into and carry into effect agreements with respect to the alteration of the width or levels of such streets or roads, the laying down, maintaining, renewing, repairing, working, and using of the proposed tramways, and the rails, plates, sleepers, and works connected therewith, and for facilitating the passage of carriages and traffic over and along the same.

(7) The tramways will be constructed on the gauge of 4 feet 8½ inches, and it is not proposed to run over any part of the proposed tramways carriages or trucks adapted for use upon railways.

(8) To authorize the company, from time to time, on such terms and conditions and subject to such restrictions (if any) as may be prescribed by the intended act, to use for moving carriages and trucks upon the proposed tramways animal power and any electrical or other mechanical power or steam locomotives.

(9) To authorize the company, from time to time, to make, maintain, alter, and remove such crossings, passing places, sidings, junctions, turn-outs, and other works as may be necessary or convenient for the efficient working of the tramways, or for facilitating the passage of traffic along streets or roads, or for providing access to any stable or carriage sheds or works or buildings of the company.

(10) To authorize the company to enter upon and open the surface of and to alter and stop up, remove, and otherwise interfere with streets, roads, highways, foot-paths, sewers, drains, pavements, thoroughfare, water-pipes, gas-pipes, and electric telegraph pipes, and apparatus within the said township of Tadcaster West, for the purpose of constructing, maintaining, repairing, removing, altering, or reinstating the proposed tramways and works, or for substituting others in their places, or for the other purposes of the intended act.

(11) To make, provide, and maintain all necessary and convenient basins, culverts, sluices, valves, soughs, cloughs, drains, piers, locks, flood-gates, banks, dams, wharves, quays, landing places, ways, roads, towing paths, passages, fences, warehouses, storehouses, sheds, weighing machines, cranes, dredges, steam-tugs, lighters, and other works and conveniences in connection with the said intended navigation.

(12) To empower the company to purchase and take by compulsion or agreement and to hold lands and easements in or over lands for the purposes of the intended navigation tramways and other works or any of them in the parishes, townships, and places aforesaid.

(13) To authorize the company to demand and recover toll rates, rents, and charges on barges and other vessels, and on goods, matters, and things in respect of the use of the navigation and the towage of barges and vessels, and in respect of wharfage, crannage, weighing-machines, warehousing, and other conveniences and appliances, and for services rendered or performed by the company in relation to any such barges, vessels, goods, matters, or things, and also for the use of the tramways, and for goods and other things conveyed thereon, and to grant exceptions from toll rates, rents, and charges.

(14) To authorize the company to appropriate, and use or sell, and dispose of the materials dredged or removed from the bed banks and fore shore of the said river, and to deposit the same if they think fit upon any other portions of the said banks or foreshores or upon any lands by agreement with the owners thereof, or in such places as the company may think proper or as may be prescribed by the intended act.

(15) To empower the company to carry on the business of carriers by land and water, and for that purpose to provide, construct, repair, let on hire or license tug-boats, barges, and other vessels, and to construct wharves, warehouses, and other works and conveniences required in connection with the operations of the company.

(16) To authorize the company to divert, alter, or otherwise interfere with, temporarily or permanently, roads, highways, lanes, passages, footpaths, water courses, drains, culverts, sewers, wharves, and other works, so far as may be necessary for the purposes of the intended act.

(17) To empower the company to deviate in the construction of the several intended works hereinbefore described from the lines and levels delineated on the plans and sections to be deposited as hereinafter mentioned to such an extent as will be defined on the said plans or provided by the intended act.

(18) To authorize the company to use for the purposes of traffic to and from their navigation any existing cuts, channels, locks, wharves, towing paths, and other works and conveniences thereon or connected therewith.

(19) To authorize the company to make by-laws and regulations for the regulating of traffic and control of vessels and boats in the River Wharfe, and for supervision over the erection of private wharves, and as to casting of rubbish and other matter into the river.

(20) To authorize agreements between the company and the Ouse Navigation Trustees with reference to the use of the undertakings of the company and of the said trustees the locks and other works thereon and connected therewith, and the interchange, conveyance, working, and accommodation of the traffic thereon upon such terms and conditions as may be agreed upon or determined by arbitration.

(21) To vary and extinguish all rights and privileges which would in any manner impede or interfere with the objects of the intended act and to confer, vary, and extinguish other rights and privileges.

(22) To incorporate with the intended act, and extend to the company so far as the same are applicable and except so far as the same may be specially varied by the intended act, the provisions of the companies clauses consolidation acts 1845, 1863, and 1869; the lands clauses consolidation acts 1845, 1860, and 1869; the land clauses (umpire) act 1833, and the tramways act 1870.

(23) And notice is hereby also given that on or before the 30th day of November instant, plans and sections showing the lines and levels of the intended works and the lands which are to be taken under the powers of the intended act, with a book of reference to such plans and a copy of this notice as published in the London Gazette, will be deposited with the clerk of the peace for the West Riding of the county of York at his office at Wakefield, and on or before the same day a copy of so much of the said plans, sections, and book of reference as relates to each parish or extra-parochial place in or through which the said works are intended to be made or will be situate with a copy of this notice published as aforesaid will be deposited with the parish clerk of such parish at his residence, and in the case of an extra-parochial place with the parish clerk of some parish immediately adjoining thereto at his residence.

(24) Printed copies of the intended act will be deposited in the private bill office of the House of Commons on or before the 21st day of December next.

Dated this 15th day of November, 1889.

BROMET, TAYLOR & BROMET,
Tadcaster, Solicitors.

W. & W. M. BELL,
27, Great George Street, Westminster, Parliamentary Agents.

PROPOSED GOVERNMENT PURCHASE OF ENGLISH CANALS.

It is said that papers have been forwarded from the board of trade to the various canal companies and trusts requesting information of a very complete character, and looking, as it is suggested, to legislation in the next (now current) session of Parliament for the acquisition by the Government of the entire canal system of the country. The rumor proceeds to the effect that leading men of all parties, recognizing the difficulty of dealing effectually with the question of railway freights under the present system of what is called virtual monopolies, have given their adherence to the principle of the state acquirement of the canals.

This is most likely a great exaggeration, and probably arises from a misconception of the first annual inquiry required by recent Parliamentary action. But the question is one which, as is well known, has for many years past attracted much attention. The last particular investigation on the part of Parliament was in 1883. In the course of this inquiry perhaps the most striking fact which was elucidated was the acknowledged and lamented lack of information on the part of the authorities, and the apparent hopelessness under the then existing arrangements of obtaining anything like a satisfactory setting forth of the condition and requirements of the canal system of the kingdom.

CANALS VS. RAILWAYS.

Although it antedates the railways as a more or less connected plan of public transportation by nearly a century, it seems to have missed the touch of that vital spirit of organization under whose influence on the other hand the railways came almost at their very inception.

The railway mania, as it is called, of the forties ruined many people who had ventured beyond their strength, but its influence upon the transportation subject was unquestionable in the way of exciting the interest of investors, engaging the services of mechanical talent, and securing the benefit of the best administrative capacity to be found in the kingdom.

From that period onward the progress has been witnessed which has resulted in the existence to-day of something like a dozen corporations who practically control the inland traffic of the island.

Originally both railways and canals were short and disconnected; built mainly with a view to local needs, and neither intended nor adopted for more extensive requirements.

In this condition the managers of railways recognized the necessity of change; those of the canal undertakings did not, or did so to a much more limited extent.

The consequence has naturally come about that in opposition to a consolidated, organized and disciplined system of steam transportation on steel rails the canals are able to show nothing more than a broken front.

Their lines appear to have been laid out as a rule with little reference to what had been or what was to come. Lengths of 15 and 20 miles were regarded as considerable projects, and these grew together by degrees, but in many instances without coalescing.

In such essential points as sections of area, as size of locks, as heights of bridges, and indeed in all the respects which facilitate or else render impossible intercommunication and mutual utilization of connecting lines, the notion of coördination, if it ever was suggested to the minds of the constructors, would appear in nearly every instance to have been expressly negatived.

In addition to these difficulties inherent in the plans adopted for the separate canals, there intervened a further element, one which has given rise to much discussion, and about which a widely varying opinion has been expressed, but which would *prima facie* look to justify but one interpretation. Since all recorded time, suggested in proverb, illustrated by fable, and proven on the pages of history, it is not a circumstance tending to the profit of the weak to be in the power of the strong. The English railway has been a lion and has left it to the canal to play the lamb. The consequence is seen in the testimony before the parliamentary committees where witnesses speak of "apathy" "lack

of spirit" and even of "creeping paralysis" on the part of the canal system; which seems to have largely arrived at the state in which neither self-help is likely nor aid from without desired.

While this discouraging view is warranted in a general examination of the present development of the English canals, there still remain some, and some very striking, exceptions. Not to refer to that bold and vigorous manifestation of what commercial enterprise can undertake and engineering skill fulfill, the ship-canal now in course of construction from Manchester to Liverpool, there are some English canals which may be profitably studied, though they are not laid out on such a scale or intended to cope with such demands of traffic as the one just named.

THE CALDER AND HEBBLE NAVIGATION.

Perhaps the most conspicuous among this last mentioned class is one whose organization, and operation are entirely or almost entirely within the limit of the Leeds consular district. It is the project whose progress has been previously described at some length, which was organized originally and which is still in part operated as a river navigation, but whose development as a canal forms its more interesting and valuable aspect for the purposes of this inquiry.

The Calder and Hebble Navigation connects the Aire and Calder Navigation with the Rochdale Canal, joining the former at Falling Lock, a quarter of a mile below Wakefield Bridge, and the latter at Sowerby Wharf, about 2 miles from Halifax. The Hebble River unites with the Calder below Salterpebble not far from the terminus of the navigation. The course of the Calder and Hebble navigation, from the beginning at Sowerby Wharf, is in an easterly direction by Elland, Cooper Bridge, near where Sir John Ramsden's Canal branches from it to Huddersfield, and on by Dewsbury and Horbury Bridge to Wakefield, where it unites with the Aire and Calder navigation, as already stated. From Sowerby Wharf the Rochdale Canal goes by way of Hebden Bridge and Rochdale to Manchester.

The Calder and Hebble navigation was originally undertaken by authority of an act of June 9, 1758. It was surveyed by Mr. Smeaton in 1757, and executed with his superintendence by commissioners under the act. Authority was given to raise money on the tolls at 5 per cent. The toll rates were: Stones, slate, flags, lime, limestone and coal, 1s. 1½d. per ton for the whole distance; all other goods, merchandise and commodities, 8s. per ton for the whole distance, and so in proportion for any shorter distance.

The exemptions from toll are: Stones, timber, gravel, sand, or other materials, for the use of the mills within the limits of this line of navigation; soapers' waste, dung, and all sorts of manure, except lime or limestone.

Coal, under this act, is prohibited from being carried down the stream towards Wakefield (except for the use of the vessels navigating the same) under the penalty of £50 (\$243.33), one-half to the King, the other moiety to the person who sues for the same.

Great damage having been suffered from a flood in 1767, application to Parliament was made by the parties who had supplied the funds for construction and an act was obtained in 1769 for strengthening the undertaking and securing the first investors. A corporation was formed with unlimited powers to raise money among themselves and authority to borrow on the tolls the sum of £20,000 (\$97,330). This legislation

repealed the first act and tonnage rates were substituted, as follows: Stones, slate, flags, lime, limestone, and coal, 4s. 2d. per ton for the whole distance; all other goods, wares, merchandise, and commodities, 9s. per ton for the whole distance, and so in proportion for any less distance or weight.

Exemption from toll.—Materials for the repairs of any of the mills on this line of navigation, soapers' waste, dung, or any kind of manure, except lime and limestone, provided such articles pass through the locks at the time when water is flowing over the dam of such locks. Boats under 15 tons not to pass without leave. Owners of wharves may charge 3d. per ton for any article which may remain less than 6 days; if more, a halfpenny per day in addition.

As to dividends, the act provides that whenever more than 10 per cent. shall be paid in any one year on the original sums expended on the navigation, then the rates shall be reduced in the year following.

Millers were required to stop their mills when the water was reduced 18 inches below the crown of the dam.

The Calder and Hebble navigation from Sowerby wharf to Fall Ing lock, that is to say, from the Rochdale Canal to the Aire and Calder Navigation, is 22 miles in length with a fall of 192 feet 6 inches by 28 locks. A considerable portion of the line occupies the original course of the river. The remainder is composed of cuts to shorten distance and avoid obstacles. With the Aire and Calder and the Rochdale Canal and their connections it forms another route from the West to the East coast. The opening of the Rochdale and the Huddersfield Canals caused a great increase of revenue and as much as 14 per cent. was declared as dividend. Previous to the development of the railway system great advantages were derived from this navigation by the country which it penetrated, particularly in facilitating the transport of flag and building stone, lime, coal, and iron ore.

In 1825 power was obtained from Parliament to extend to Halifax (only 1½ miles). One hundred and ninety-four thousand six hundred and sixty dollars was authorized to be raised among themselves and \$48,665 by way of loan or by new shares, with the option of issuing promissory notes or pledging the tolls.

The limitation of dividend was repealed by this act and the tonnage rates altered to read as follows: Stones, slate, flags, lime or limestone, and coal 2s. 2d. per ton for the whole distance, all other goods, wares, merchandise, and commodities 4s. 1½d. per ton for the whole distance, and in proportion for any less weight or distance. Fractions to be taken as for a quarter of a mile and as for a quarter of a ton.

These rates came into force for the whole line June 1, 1825. The gross receipts about 1830 amounted to about \$194,660 per annum.

The cut authorized by the last act is nearly 1½ miles in length with a rise of 100 feet 6 inches. The water is obtained by a drift 1,170 yards long to a pit from which it is raised by steam-power to the head level. So novel and expensive a method was adopted in order to avoid disputes with mill owners.

Sir John Ramsden's Canal, authorized by act of March 9, 1774, commenced near Cooper's Bridge on the Calder and Hebble navigation, and thence runs in a southwesterly direction to the King's Mill near Huddersfield, where it joins the Huddersfield Canal, which goes from Huddersfield to a junction with the Ashton-under-Lyne Canal, leading from Ashton to Manchester, and connecting by way of the Rochdale and the Duke of Bridgewater's Canals to Runcorn and thence by the river Mersey to Liverpool.

Sir John Ramsden's Canal is about $3\frac{3}{4}$ miles in length with a rise of 93 feet. Though so short it is of importance as one of the links in the chain between the two seas and as a means of communication with the prominent manufacturing center, Huddersfield. The act allows 1s. 6d. per ton on all goods. It may be noted that the owner of the canal owned also the entire town of Huddersfield, one lot or so excepted. This canal was afterwards (about 1845-46) purchased by the London and Northwestern Railway Company.

The Huddersfield Canal was suggested by the evident convenience to be derived from connecting Huddersfield and Ashton-under-Lyne, from which points other canal and navigation undertakings previously entered on gave the possibility of another and the shortest through line of water ways from Hull to Liverpool. This course included the Humber and the Ouse Rivers from Hull to the Aire and Calder navigation and on to Wakefield; thence by the Calder and Hebble to Sir John Ramsden's Canal, and thereby to Huddersfield, where the new project would begin and take the traffic as far as Ashton, where it would reach the canal, then, in 1793, in a great state of forwardness and designed to enter Manchester, where a short cut, (afterwards obviated by the construction of the Rochdale Canal gave communication with the Duke of Bridgewater's Canal) Runcorn, and Liverpool. In 1794 the act of incorporation passed, giving authority to raise in shares of £100 (\$486.65), each the sum of £184,000 (\$895,436), and if necessary £90,000 (\$437,985) in addition amongst themselves, or by new shares or by mortgage. The act established the following:

Tonnage rates.

All dung, manure, clay, sand, and gravel not passing a lock..... per ton per mile..	$\frac{1}{4}$
All dung, manure, clay, sand, and gravel passing a lock..... do.....	$1\frac{1}{4}$
All lime, stone, coal, cannel, or other minerals not passing a lock..... do.....	1
All lime, stone, coal, cannel, or other minerals passing a lock..... do.....	2
All timber, goods, wares, merchandise, and other articles not before mentioned, per ton per mile.....	3

For all stone, lime, coal, cannel, timber, minerals, goods, wares, merchandise, and all other articles passing along or through the tunnel on the summit level, or any part thereof, in addition to the above rates the further sum of 1s. 6d. per ton.

Fractions of a mile to be taken as a mile; of a ton as the quarters of a ton contained therein; and of a quarter as a quarter.

Wharfage rates to be demanded by the company or others having wharves on the line of the canal shall not exceed 3 pence per ton for the space of 10 days, after which time an additional charge may be made for every succeeding day of one halfpenny per ton per day. Vessels of less than 10 tons are not to pass a lock when the water does not run over the weir, nor of 15 tons when it does, without leave of the company's agent, to be given in writing.

Reservoirs are to be made by the company to contain not less than 20,000 locks of water, each lock being 180 cubic yards; none of this water (except in time of flood) to be taken from the rivers on the line. Sir John Ramsden is guaranteed against any loss on his canal arising from the new project.

Provisions are made against detriment to the mills in the vicinage, and diminution through the tunnel of certain waters is to be made up to the neighborhoods affected. Further extension easterly, if made to the prejudice of the Ramsden, Aire and Calder, or Calder and Hebble undertakings is to be accompanied by reparation to parties suffering damage, who are to receive all rates and tolls in due proportion.

The canal from Huddersfield to Marsden was opened in 1798, and also that between Ashton-under-Lyne and Stalybridge. A further part from Stalybridge was also navigable, but owing to the great expense of the tunnel and failure to get payment of subscriptions the canal made slow progress. The company succeeded in raising on mortgage only £14,182 (\$69,016.70), and having spent all their money they applied again to Parliament and obtained in 1800 a second act. Under this they were empowered to make calls not exceeding £20 (\$97.33) per share in the whole and to raise by new shares or through long-term promissory notes any necessary sum not exceeding altogether the original limit of £274,000 (\$1,333,421.) The costs however proved to be so much beyond the calculations that recourse was again made to Parliament, and a third act obtained in 1806 before the canal could be successfully completed.

This canal was constructed for craft 7 feet wide and such as were navigating upon the Staffordshire and southern canals. It was capable of passing boats with 24 tons burden. From Huddersfield its course is southwesterly past Slaithwaite, crossing the river three times on aqueducts, and by an ascent of 436 feet distributed among 42 locks and a length of $7\frac{1}{2}$ miles it comes near Marsden to the summit level, which was at the time of construction the highest of any in the kingdom, 656 feet above the sea. By a tunnel 5,451 yards long it passes under the Pemrine Range and to the neighborhood of Wrigley Mill, a total length of summit level of 4 miles. Thence by Dobcross and Stalybridge to the Ashton junction is $8\frac{1}{2}$ miles, with a descent of $334\frac{1}{2}$ feet through 33 locks, crossing the River Tame in four places and making a total length of canal of $19\frac{1}{2}$ miles. Between the summit and Ashton are two other tunnels; one at Scout, 204 yards long, through strong sand rock, and the other near Ashton, 198 yards long, through fine sand.

The principal or Marsden Tunnel was 9 feet wide and 17 feet high, depth of water 8 feet, leaving 9 feet to the spring of the arch. There was no towing path in the tunnel, and boats were passed through by hand, taking 1 hour and 20 minutes. At Scout and at Ashton there were towing paths.

This connection is one of three lines uniting the Aire and Calder navigation with Liverpool, to wit, the Leeds and Liverpool from Leeds, the Calder and Hebble and Sir John Ramsden's with the Huddersfield, and Ashton-under-Lyne from Wakefield, and also from Wakefield the Calder and Hebble and the Rochdale, both the latter lines coming together at the end of the Rochdale line at Manchester, whence the Duke of Bridgewater's Canal takes up the traject to Runcorn and the Mersey. The line over the Huddersfield Canal is called the shortest by $9\frac{1}{2}$ miles. It passes through a densely populated manufacturing district full of valuable stone, but otherwise subject to supply from other districts.

The original estimate was £184,000 (\$895,436), but upwards of £300,000 (\$1,459,950) had been expended at the date of Mr. Priestley's account 1830.

The Huddersfield Canal was amalgamated with the London and Northwestern Railway Company in 1845-'46.

The third route referred to above, namely, that by the Calder and Hebble and the Rochdale Canal, was begun as regards the Rochdale portion under act of Parliament of 1794.

Its course was from the Calder and Hebble Navigation at Sowerby Bridge wharf and westward thence up the valley of the Calder by Hebden Bridge to Todmorden; passing Todmorden and bending southward it proceeds to Warland where the summit level began; thence in

a generally southerly direction, with a branch to the neighborhood of Rochdale, to near Failsworth, whence turning a little more to the westward it locks into the Duke of Bridgewater's Canal at Castlefield, Manchester, having received the Ashton-under-Tyne Canal at Piccadilly wharf about a mile from the junction at Castlefield.

According to the levels of Mr. Reunnie, the engineer to this work, the rise from Sowerby to where he proposed the summit level to begin, near Travis' Mill, was 275 feet in a distance of about $11\frac{1}{4}$ miles, and the fall thence to the Duke of Bridgewater's Canal 438 $\frac{1}{2}$ feet.

In 1806 the works had already cost £328,900 (\$1,600,591.85), but were still unfinished though the canal was partially opened. One hundred and forty-three thousand and fifty pounds (\$696,152.83) was said to be then still required for the completion of the whole, which was provided for by the act in that year (1806.)

The Barnsley Canal, $15\frac{1}{4}$ miles in length, was incorporated in 1793, the proprietors being one hundred and thirteen in number and consisting largely of the landholders of the district. They were empowered to raise £72,000 (\$350,388) among themselves, in 720 shares of £100 (\$486.65) each, with further power up to £20,000 (\$97,330), for which last they might pledge the rates.

The canal begins at the River Calder (Aire and Calder Navigation), three-quarters of a mile below Wakefield Bridge and about three-eighths of a mile below the junction, at Fall Ing Lock of the Calder and Hebble Navigation with the Aire and Calder. It rises from the Calder 117 feet by fifteen locks in the distance of $2\frac{3}{4}$ miles; thence on a level to the crossing by an aqueduct of the river Dearne, at the south side of which, 10 miles from its commencement at the Calder, it forms a junction with the Dearne and Dove Canal. From the aqueduct the Barnsley Canal, still on a level, turns westward parallel with the River Dearne, passes near Barnsley, and on to the neighborhood of Barugh Mill, where the long level terminates, 11 miles in length. From this place to the end of the canal, at Barnby Basin, there is a rise of 40 feet by five locks in a distance of $1\frac{3}{4}$ miles.

The rates of tonnage allowed under the incorporating act of 1793 were as follows:

	d.
Wheat (shelling), beans, pease, vetches and lentils, rape, line, cole, and mustard seed, apples, pears, and potatoes per quarter for the whole length..	6
Barley	5
Oats and malt	4
Pack or sheet of wool, dried pelts or spetches, per 312 pounds for the whole length.....	6
Coal, slack, cinders, culm, charcoal, and lime per ton per mile..	1
Limestone.....	$\frac{1}{2}$
Stone, ironstone, flag, paving stone, and slate	1
Pig or old iron	$1\frac{1}{4}$
Cast metal goods and bar iron.....	2
English oak, timber, and planks..... per 40 cubical feet per mile..	$1\frac{1}{4}$
Elm, oak, and other English timber	$1\frac{1}{4}$
Fir and all other kinds of foreign timber	$1\frac{1}{4}$
Deals and battens, equal to thirty deals of 12 feet long, 3 inches thick, and from 9 to 12 inches broad.....	$1\frac{1}{4}$
All other things not before enumerated	2

That 10 superficial yards of flag paving stone, from 1 inch to $2\frac{3}{4}$ inches in thickness, or 16 cubical feet of stone, to be deemed a ton.

The only railway belonging to this company, made under the authority of the before-mentioned act, was $1\frac{1}{4}$ miles in length, running from Barnby

Basin (the end of the canal) to Norcroft Bridge, near the Silkstone collieries.

Tonnage rates on the railway.—Coal and other minerals, 3d. per ton per mile. From the preamble of an act passed in 1808 the company appears have expended the entire sum authorized by the first act in the canal alone, and were in debt. They therefore obtained power to raise the further sum of \$210,232.80 by a call of £60 (\$291.99) on every shareholder of £100 (\$486.65), and also to raise £10,000 (\$48,665) on mortgage if needed. Rates of tonnage are raised one-half by this act, except as to that part of the navigation between Barnby Basin and the junction with the Dearne and Dove Canal for vessels passing from or to the Dearne and Dove Canal, or on the railways connected with this portion of the Barnsley Canal. An exception is also made for flag paving stone, limestone, or lime on this part of the canal, which has previously been carried on the Dearne and Dove Canal.

The principal object in constructing this canal was to open the extensive coal fields near Barnsley and Silkstone.

The depth of the canal was 5 feet, width of locks 15 feet, and length 66 feet.

When the call of \$291.99 per share of £100 (\$486.65) was made under the second act many shareholders threw over their shares at £5 (\$24.33) apiece, after having advanced all called for by the first act. These same shares in 1829 were valued at £325 (\$1,581.61) per share. The canal was opened in 1799, but the railroad to Silkstone was not commenced until after the passing of the act of 1808.

This canal was bought by the Aire and Calder in 1871, and improved by them as noticed previously in this report.

This report is accompanied by a sketch map of the region from Hull to Liverpool. Speaking generally, the foregoing details with regard to the inception and construction of the canals described (except in such instances as where the mention of later dates or other indication precludes this supposition) are derived from Mr. Priestley's work referred to in the early part of this report, and where read in the present tense they should be understood as stated from the point of view of 1830, the date of that work (published 1831).

EXTENT OF BRITISH CANALS.

The great absorption of canals by railway companies occurred from 1845 to 1850. The canals were frightened into combination with the railways. The result was to cripple the canal system of the kingdom. At the time this took place neither had the transportation trade of the country been developed nor had the capacity of the canals been demonstrated. Another witness says the greater number of consolidations (canals with railways) took place in 1846. In the movement then in full force for obtaining from Parliament the desired authority for construction the new undertakings were opposed by the existing canal companies. The outcome of this was seen in the subsequent arrangements entered into by the railways with the canal companies, under which, by means of guaranteed dividends in some instances, and in others by outright purchase, the canal opposition was overcome or neutralized. Another witness estimates in 1883 that of the narrow-gauge canals, which are especially those whose interposition on through routes is detrimental, quite 700 miles in England were under railway control.

The total mileage of railway-influenced canals is variously stated.

Mr. Calcraft for the board of trade in 1883 handed in the following figures :

	England.	Scotland.	Ireland.	Total.
Length of canals, etc., owned or controlled by railway companies.....	1,250½	85	92	1,430½
Length of canals, etc., owned by other than railway companies.....	1,428½	.....	164	*1,592½
Total.....	2,688	85	256	3,029

* These lengths are exclusive of the rivers Thames, Severn, Wye, Humber, Wear, and Tyne in England; the rivers Clyde, Forth, Tay, and the Caledonian Ship Canal in Scotland; and the Shannon and other navigations in Ireland.

Mr. Calcraft also gives the following statement of the canals, etc., owned or controlled by railway companies on December 31, 1882, by dates of the special acts of authority: ,

	England.	Scotland.	Ireland.	Total.
Under acts of—	<i>Miles.</i>	<i>Miles.</i>	<i>Miles.</i>	<i>Miles.</i>
1845.....	78½	.....	92	170½
1846.....	774½	.....	.....	774½
1847.....	96½	.....	.....	96½
1849.....	20½	32	.....	52½
1852.....	86½	.....	.....	86½
1862.....	3½	.....	.....	3½
1864.....	74	.....	.....	74
1865.....	34	.....	.....	34
1866.....	15½	.....	.....	15½
1867.....	.....	53	.....	53
1870.....	50	.....	.....	50
1872.....	17	.....	.....	17
1883.....	9½	.....	.....	9½
	1,250½	85	92	1,430½

Another gives canals and inland river navigation under control of railways in—

	<i>Miles.</i>
England.....	1,062½
Scotland.....	106
Wales.....	70
Total.....	1,238½

Against not under such control in—

England.....	1,260½
Scotland.....	84½
Wales.....	53½
Total.....	1,403

Rivers in England under railway control.....	209½
Against same uncontrolled.....	932½
Canals and navigations abandoned or converted into railways.....	250½

Whitaker's Almanac for 1890, a usually reliable authority, states that it is impossible to say with exactitude what is the total length of the canal and inland river navigation of the United Kingdom. The article proceeds to give different sums for the total mileage as furnished from different sources:

The Board of Trade.

	<i>Miles.</i>
United Kingdom, excluding certain rivers and a ship canal, as named.....	3,029

Another authority.

England and Wales alone (canals)	4,050
England, Scotland, and Wales (canals)	4,033
Inland navigation, England and Wales	4,333
Scotland	354
Ireland	755
Nonnavigable rivers—feeders	1,875
	<hr/> 7,317

In the last item the figures curiously reproduce an error which appears in the evidence of Mr. Conder before the select committee of 1883, from which apparently the compiler has copied the statement without verifying the addition.

Whitaker's Almanac itself gives a table showing for the whole Kingdom—

	Miles.
Canals, etc., not owned by railway companies	1,547
Canals, etc., owned by railway companies	1,421
Total	<hr/> 2,968

Of which, so far as indicated, there are in Ireland 164 miles independent and 92 railway controlled, and in Scotland 85 under railways, which would give a net mileage for England, or England and Wales, independent, 1,383; railway, 1,244, or a total of 2,627 miles.

Still another tabulation for England and Wales estimates—

	Miles.
Independent canals	1,445½
Canals and navigations under public trusts	927½
Same controlled by railways	1,348
Derelict	188½
Ownership not known	36½
Converted into railways	119½
Total	<hr/> 4,065½

These last figures are accompanied by details which do not quite accurately answer to the summary. The difficulty of obtaining definite and coherent information in the way of canal statistics in England is constantly commented on by the persons coming before the select committee, and the printed proceedings of the inquiry support the complaint in a very marked manner. As approximations, nevertheless, are better than no information at all, I have endeavored to embody results, and to give a general idea where particular correctness might be unattainable. One of the witnesses before the committee says: "The length of the canals that I have given you has been taken, as you may say, from literary sources alone." The necessity for more thorough acquaintance with the actual outcome of the canal operations has been so persistently urged that the Government is now engaged in an effort to collect details of work from the whole body of canals in the Kingdom with a view, as the report goes, to considering the advisability of itself assuming control of the system. This report is, perhaps, questionable.

In the testimony before the select committee one finds more than once an expression like this: "The canals are struck with creeping paralysis, with all these obstructions."

The charge is made, and, while not acknowledged by the railways, the accusation seems well founded, that following upon the acquirement in the early days of their organization by the railways of short and intercepting links of canal routes, the wonderful development of the railways themselves was accompanied by a diminution of power on the part of the canals, or at least by an absence of growth and vigor, so

marked as to in some sort demand explanation. This explanation is in large degree afforded by the attitude attributed by many witnesses to the railway companies in their dealings with their own acquired canal interests and with those of the canal companies whose lines traversed the same districts.

Mr. Lloyd, in his evidence, as a remedy for the acknowledged weakness of the canals, recommends unity of administration between central points. In this position it may be said generally that he is supported by all the testimony offered on behalf of the canals. As a preliminary to better things entire alienation from railway control is desired by the more thoroughgoing opinion; and indeed it seems difficult for an observer to understand how the present conditions could have been deemed avoidable, or how any decided and permanent betterment could be anticipated, with vital portions of the main through canal routes of the Kingdom in the hands of those whose business was identical with, and whose methods so diametrically diverse from, those of the canal companies. Sir H. Bartle Frere, Bart., testifying in 1883, says that railways had a feeling that canals were a delusion, and that it was their proper function in life to supersede them entirely by railways. Many connected with railways still preserved that feeling. A certain weight of the evidence favored this so-much desired uniformity being obtained by means of government authority acting directly. Otherwise private management was regarded sufficient for effective operation. The need of information, however, was distinctly indicated in the course of the investigation. This of course could scarcely be acquired in the way and to the extent wished for without government intervention; and, as already stated, the Government is now taking action looking that way.

The need for improved water transportation seems peculiarly to be felt with reference to the important centers of production and distribution in the interior; points ranging in distance from the sea from 30 or 40 miles upwards. Where sea freights intervened the railway rates were said to be kept down; but with many of the most important places railways supplemented by canals are the sole reliance.

COST OF CANAL AND RAILWAY MAINTENANCE.

During the inquiry conducted in 1883, a number of estimates of cost were brought to the notice of the committee. A brief conspectus may be of interest.

In a report dated 1882, Mr. Conder, a distinguished engineer, whose recent death has caused such regret in his profession, gives a table of comparative cost between railway and canal as follows:

Out of every £200 (\$973.30) paid for an equal tonnage transported an equal distance the detailed costs are:

	By rail- way.	By canal.
	Per cent.	Per cent.
Maintenance of way.....	12	0.0
Maintenance of works.....	7	2.3
Repairs of rolling stock.....	19	6.0
Traction.....	16	8.0
Traffic expenses.....	30	6.0
General charges.....	15	15.0
Interest on capital.....	100	33.3
Total.....	200	70.6

Showing an economy of 64.7 per cent. by canal.

He gives M. Krantz's estimate for French canals as follows: On continental water transport cost is divided into tolls and freights: Owner of canal takes the tolls, paying out of them maintenance and any interest or dividend; all other charges come under the head of freight.

Cost of transport for new navigation.

	100,000 ton miles.	Per ton per mile.
Equivalents of tolls:	£. s.	d.
Interest and redemption (sinking fund)	65 0	0.15600
Maintenance	9 4	0.02208
Equivalents of freights:		
Traction (in table £36 6s.)	86 16	0.08822
Boats	30 6	0.08712
Empties	21 8	0.05076
Total	168 9	0.40428
Deducting interest and redemption	65 0	
Leaves for haulage, boats, and maintenance	103 9	

The total, £168 9s., is in federal currency, 0.82 cent per ton per mile total cost of transport; and for haulage, boats, and maintenance, £103 9s.

£103 9s. gives 0.5 cent per ton per mile. The incidence for freight is approximately the same per unit irrespective of quantity of traffic. That of interest and maintenance (the equivalent of tolls) depends on ratio of receipts to capital. M. Krantz is cited as giving cost of maintenance on two minimum amounts of traffic which are reckoned sufficient to be profitable on canals on 500,000 tons per annum, .045 pence = .091 cent per ton per mile; 1,000,000 tons .0225 pence = .046 cent.

Mr. Conder quotes the cost of carriage for several different centers:

	Per 100,000 ton miles.	Per ton per mile.
		d. cent.
Austrian Canals, Danube navigation, Galatz to Saliva	£104. 16	0.24998 = 0.51
Belgian Canals	180. 25	0.31260 = 0.63
Louvain and Ruppel Canals	83. 80	0.19892 = 0.40
Alsace and Lorraine Canal	154. 16	0.36098 = 0.75
Saarbrück Canal	101. 25	0.248 = 0.49
Chicago to New York	41. 80	0.09912 = 0.20

NOTE.—These figures presumably include haulage, boats, and maintenance, but make no allowance for capital.

He makes approximately the cost of carriage on the French canals (including haulage, boats, and maintenance but not including capital—interest and redemption) to amount to 1 farthing (half a cent) per ton per mile on the existing canals. On the new ones, where capital and sinking fund are reckoned with, he gives 0.4 penny, 0.8 cent, as the cost. In the old canals the capital is supposed to be sunk.

On English canals, allowing cost of a mile to be £15,000, (£72,997), it would make total cost of carriage, including capital, by Mr. Conder's reckoning:

	100,000 ton miles.	Per ton per mile.
		Cent.
Interest	£42. 375	0.21
Maintenance	9. 450	0.04
Traction	36. 250	0.18
Boats	31. 250	0.15
Empties	31. 250	0.15
	150. 575	0.74

On Forth and Clyde Canal Mr. Conder gives £33.3 (0.16 cent per ton per mile) for horse towage only; £95.8 (0.47 cent per ton per mile) including all costs; Gloucester and Berkeley Canal £37.5 (0.18 cent per ton per mile) steam towing; River Lea £138.8 (0.67 cent per ton per mile) covering all costs; River Thames (no maintenance, etc.) £41.6 (0.20 cent per ton per mile), tugging alone by steam tugs.

On a cost of construction per mile of railway, which Mr. Conder reckons for those of England and Wales £46,800, and for the United Kingdom £40,000, he estimates, on a traffic of 600,000 tons net load, that cost of interest would be per mile for the last-named 0.68 penny, and for working expenses 0.53 penny, making total cost per ton per mile 1.21 pence.

COST OF FREIGHT BY CANAL AND RAILWAY.

In a tabulated statement submitted by him in 1883, to the select committee, he gives figures from which the following are extracted; showing comparative cost of traffic 600,000 tons net per annum. Interest $\frac{4}{2}$ per cent. on capital.

	Miles.	Cost per milo.	Interest.	Work- ing ex- penses.	Cost per ton per milo.	Cost 100,000 units.	Per ton per mile.
		£.	d.	d.	d.	£.	Cents.
United Kingdom:							
All railways.....	17,000	40,000	0.68	0.53	1.21	504.0	2.45
English railways.....	12,856	46,800	0.78	0.53	1.31	587.5	2.65
English canals.....	4,332	6,560	0.11	0.26	0.37	154.0	0.75
English canals (ex interest).....	4,332			0.12	0.12	50.0	0.24
English canals (minimum).....	4,332			0.05	0.05	20.8	0.10
France:							
Railways.....	15,177	25,780	0.44	0.42	0.86	318.0	1.74
Canals.....	7,069	6,229	0.10	0.23	0.33	137.0	0.67
Belgium:							
Railways.....	1,196	26,403	0.45	0.49	0.94	392.0	1.90
Canals (redeemed).....	1,254			0.20	0.20	83.3	0.41
United States:							
Railways.....	84,225	11,629	0.15	0.27	0.42	166.0	0.85
Canals (minimum).....				0.10	0.10	41.6	0.20
By sea:							
Coasting steam colliers.....			0.038	0.116	0.155	64.5	0.31
Lowest sea freight (Ex. 12 s. 6 d. per ton).....					0.05	20.8	0.10

It may be added that in transcribing the above details some evident typographical errors have been corrected, and that some discrepancies still remain as taken from the table. The right-hand column has been added, giving federal values for the sterling cost per ton per mile approximated to two decimals.

The following is an estimate (submitted by Mr. J. S. Watson in 1883) of what could be done on an improved canal route:

Statement of cost of canal transport between London and Liverpool if effected with 3 boats (84 by 12 feet by 6 feet 3 inches draft) carrying 120 tons each, and towed by similar sized steam barges carrying 90 tons (450 tons in all) exclusive of canal tolls.

[Time for journey 5 days, with 2 days to load, 2 days to unload, and 1 spare day, say 10 days. The time for journey might be reduced if the boats worked all night, without increasing the cost.]

Total cost of new 120-ton barges, £620 each.

	£	s.	d.
Hire of barges, the owners doing repairs, £100 per annum (6s. 8d. per day for each barge for 300 days); 4 barges, 10 days.....	13	6	8
Wages (9s. per day for each barge), 4 barges, 10 days.....	18	0	0
First cost of machinery (new), £600.			

Haulage, 18 horse-power, nominal, fitted in steam barge:

	£	s.	d.
Hire of machinery (£120 per annum), 8s. per day, 10 days.....	4	0	0
Wages of engine-drivers, 10s. per day, 10 days.....	5	0	0
Coals, oils, etc. (5 days' steaming).....	3	0	0

Expenses, incidental (say 1s. per day), 10 days, 4 barges.....	12	0	0
----------------------------------------------------------------	----	---	---

Net cost of transport if the carrier paid hire rates for all his plants..	45	6	8
Profit (say 25 per cent.)	11	6	8
Cost of transport of 450 tons would be (\$275.77)	56	13	4

This is equal to 2s. 6½d. per ton, and might fairly be reckoned at 3s. (73 cents) per ton, exclusive of the canal tolls.

Cost of canal transport as now carried between London and Preston Brook (for Liverpool) in two 25-ton canal boats exclusive of canal tolls.

[Time for journey, 8 days, with 1 day to load and 1 day to unload and 2 spare days, say 12 days.]

Total cost of new 25-ton boats, £130.

	£	s.	d.
Hire of boat-owners doing repairs, £30 per annum (2s. per day for 300 working days); two boats, 12 days	2	8	0
Wages (8s. per day per boat), 2 boats, 12 days	9	12	0
Haulage, one horse to each boat.			
Horse hire (2s. 6d. per day), horse keep and expenses, 3s. 6d. per day, 2 boats, 12 days, 6s. per day	7	4	0
Expenses, incidental (8d. per day per boat), two boats, 12 days.....	16	0	0

Net cost if the carrier paid hire rates.....	20	0	0
Profit, say 25 per cent.....	5	0	0

Actual cost at present time for 50 tons (\$126.66)..... 25 0 0
10s. per ton exclusive of tolls = \$2.43.

The present tolls charged on ironwork from London to Preston Brook are:

	Distance.	Rate per ton.		Per ton per mile.
	Miles.	s. d.	d.	Cents.
Grand Junction	96	1 8	½	0.4055
Oxford Canal	24	8	½	0.6759
Coventry Canal	22½	5½	½	0.5089
Birmingham Canal	5½	6½	½	2.0277
Coventry Canal	5½	2	1 ½	0.6759
North Stafford Canal, or Trent & Mersey	67	1½	½	0.6759
		*5.2		

*\$1.26.

At Preston Brook transshipment into larger craft is necessary, for which through the remaining 20 miles the Bridgewater Navigation Company charge a trader 7s. 6d. per ton = \$1.82. The usual rate charged by canal carriers from London to Liverpool is 20s. to 22s. per ton on ironwork (4.87 to \$5.35).

The following figures are extracted from tabular statements handed in to the select committee in 1883 by Mr. Thomas Thorpe, of the firm of Barkworth & Spalding, of Hull and Gloucester, timber and slate merchants, whose business had been established at that time for over 100 years. The per ton per mile rates "delivered elsewhere" are added; as also the averages:

H. Ex. 45—14

Comparison of rates for timber and deals where there is railway and canal competition, based on the nearest rail route.

	Per rail, station to station, and delivered on canal.			Per ton per mile delivered, railway station or on canal.	Per ton per mile delivered elsewhere.	Per canal to Birmingham.	
	Miles.	Rate.	Delivered elsewhere than on canal or at station.			Rate.	Per ton per mile.
To Birmingham, from—		<i>s. d.</i>	<i>s. d.</i>	<i>d.</i>	<i>d.</i>	<i>s. d.</i>	<i>d.</i>
Gloucester	54	5 10	7 0	1.29	1.56	5 0	1.11
Bristol	91	7 8	8 6	1.01	1.12	7 6	.98
Cardiff	107	9 8	10 10	1.08	1.21	8 4	.93
Averages.....	84	7 9	8 9	1.13	1.30	6 11	1.01
To Wolverhampton, from—							
Gloucester	65	6 4	7 6	1.16	1.38	5 6	1.01
Averages.....	79	7 4½	8 5½	1.13½	1.32	6 7	1.01
Averages U. S. money	79	\$1.79	\$2.06	\$0.023	\$0.027	\$1.60	\$0.02

Rates per rail on timber and deals to places where there is no canal competition, based on the nearest rail routes.

From—	To—	Miles.	Rate.	Per ton per mile.
			<i>£ s. d.</i>	<i>d.</i>
Gloucester.....	Ross.....	18	4 2	2.77
	Leominster.....	42½	8 4	2.35
	Hereford.....	30	5 0	2.00
	Ludlow.....	53½	8 4	1.88
	Reading.....	78	10 0	1.53
Chettenham	Birmingham.....	47	6 8	1.70
	Wolverhampton	60	8 4	1.66
Total		329	2 10 10	13.87
Averages		47	7 8	1.86
Averages U. S. money.....		47	\$1.76	\$0.04

In 1883 Mr. Bartholomew, speaking for the Aire and Calder, says that there are certain railway rates, and the Aire and Calder carry at a certain rate differential from these rates as being lower. For example, a 5s. (\$1.21) rate by railway would answer to a 4s. 7d. (\$1.11) rate by the canal, a 10s. (\$2.43) railway to a 9s. 2d. (\$2.23) by canal, or just about a penny (2 cents) in the shilling (24 cents), or about 8½ per cent. less than the railway. There were also the private carriers on the canal who compete with the canal company, and sometimes make lower rates than the company.

Working expenses of an average canal, including maintenance but not including interest on first cost of construction, Mr. Abernethy, in 1883, thought should not exceed 35 per cent. of the gross receipts. He considered the cost of maintaining canal walls no more than those of docks.

Mr. Conder states that on the Suez Canal in 1882 maintenance and repairs cost 7.2 per cent. of the gross revenue. He says also that on an English canal 31 per cent. of gross receipts should pay all expenses, and regards that indeed as rather too high an estimate.

Mr. Conder in 1883 takes the position that mineral traffic on railways is of doubtful value to them as a general thing, and estimates an increase in the railway dividends of £7,000,000 per annum as likely to arise from throwing the heavy traffic on canals. He reckons the cost of conveying coal to be 0.838 penny (1.699 cents) per ton per mile on a

moderately costly railway, not one specially constructed for carrying minerals and carrying them without interference with other traffic, but one constructed for ordinary purposes and having an extraordinary mineral traffic, for which it was not designed, brought upon it. He instances the Great Western Railway, and states the capital at £78,722,000 (£383,100,613), and taking the length as 2,139 miles, he gets a cost of £36,000 a mile (£175,194), with an income of £6,869,499 (£33,430,416.88) from the gross income he deducts the cost £3,515,499 (£17,108,175.88) and obtains a net income of £1,568 (£7,630.67) per mile. The company were then sending 1,000,000 tons of coal to London (915,000 in 1877) carried 204 miles for 0.43 penny (.87 cent), presumably meaning per ton per mile. Mr. Conder puts the loss on this traffic at £155,000 (£754,307.50), and estimates that it could be carried by canal at a saving of £311,400 or \$1,515,428.10.

Mr. Conder argues if you are carrying part of your traffic at 0.4 penny per ton per mile, and your average cost for that unit is 1.31 pence, that you have 0.9 penny to charge on something else or to take out of the shareholders' pockets.

Lieut. Gen. Randall, R. E., in 1883, says that effective water carriage would be no detriment to railways, but merely leave them to take the traffic they are best adapted to. He also says with regard to water transport, that wherever the cost is not less than that of the railways it is owing in the main to imperfections in the carrying machine itself or in some of its parts, either in the dimensions of the canal and locks or in those of the boats, or perhaps in the original alignment of the canal itself. General Randall continues: "On the other hand on canals improved like the Aire and Calder has been, the cost of carriage is capable of being reduced to an astonishingly low figure with profit to the shareholders." He adds that comparisons between the efficiencies of railways and canals in their respective present conditions are comparisons "between two machines which exist under very dissimilar circumstances."

In 1874, as stated also by Mr. Conder, the Great Northern Railway (which runs from London to Yorkshire) earned gross income for mineral traffic 18.6 per cent. of the total revenue. Out of 71 trains, 33 trains carrying minerals occupied the line 13½ hours out of 24 hours, or 56 per cent. of the entire day.

Fifty-six per cent. of the capital cost, per mile, is £26,000, upon which 4½ per cent. is £1,170. In this case, however, the mineral traffic paid only £829, showing a deficiency on the gross earnings of the mineral traffic £341, comparing gross revenue from minerals per mile with net revenue required to pay 4½ per cent. on capital cost per mile of road used; 56 per cent. of the earning capacity of the line having been occupied in earning 18.6 per cent. of gross revenue.

Mr. Abernethy, speaking in 1883, says it is not possible for railways to convey raw material as cheaply as canals. He alludes also to the importance, as regards the iron interest, of having raw material carried cheaply to the foundries. He considers that a vessel of 150 or 200 tons on a canal for raw materials would afford greater accommodation to a manufactory than a railway could. Mr. Abernethy was at that time consulting engineer to the projected Manchester Ship Canal. He predicted that if the Manchester Canal bill should pass, canal companies would spring up all over the kingdom.

In a note to a paper read November 30, 1882, before the Manchester Statistical Society, Mr. Conder, C. E., gives the following details of the net and gross earnings of an average mile of English railway:

From passengers	£1,500
From goods	1,220
From minerals	768
Total	3,488
Working charges	1,855=53½ per cent.
Undistributed net earnings	1,633=46½ per cent.
Taking passenger freight at 16.6d. per ton, tare at 96 per ton; goods at 1.1d., tare at 65; mineral freight at 0.5d., tare at 56.	

	Freight per net ton per mile.	Gross re- ceipts permile.	Tare.	Net tons (ratio).	Net tons per mile.	Gross tons per mile.
	d.	Pounds.		Pounds.		
Passenger	16.6	1,500	96	{ 1,500 16.6d. }	21,818	545,450
Goods	1.1	1,220	65	{ 1,220 1.1d. }	268,181	760,529
Minerals	0.5	768	56	{ 768 .5d. }	368,040	837,818
Total			-		658,039	2,143,797

2,143,797 gross tons per mile, costing for working charges £1,855, gives per gross ton per mile for cost of working expenses..... 0.2076d.
 545,450 gross tons per mile passengers, yielding gross receipts £1,500, gives 0.66d. per gross ton per mile for gross receipts. Working expenses per gross ton per mile..... 0.2076

Net earnings passenger traffic per gross ton per mile (68½ per cent.)... 0.4524
 760,529 gross tons per mile goods yielding gross receipts £1,220 gives 0.385d. per gross ton per mile for gross receipts. Working expenses per gross ton per mile..... 0.2076

Net earnings goods traffic per gross ton per mile (46 per cent.)..... 0.1776
 837,818 gross tons per mile minerals, yielding gross receipts £768, gives 0.22d. per gross ton per mile for gross receipts. Working expenses per gross ton per mile..... 0.2076

Net earnings mineral traffic per gross ton per mile (5.3-5 per cent.)... 0.0124

The tare was obtained as set forth below, and represents proportion dead weight to paying load, and is noted as a percentage of the gross load.

Passenger tare.—Royal Commission on Railway Accidents, 1877, report, averaging weights and number of seats in a London and North-western, a Great Northern and a Midland train as reported, and allowing one seat in 4 to be occupied (the known French proportion) gives passenger tare 96 per cent. of gross load.

Merchandise tare.—The mean merchandise tare of railways cited in Table 2 (Indian, French, England, etc.), in each of which this is definitely ascertained.

* *Mineral tare.*—Weights and capacities of best types of mineral wagons on London and Northwestern; Northeastern; Great Northern and Midland Railways, mean of these wagons, if full, contains 1 ton 12 cwt. 3 qrs. of coal to 1 ton of tare, which return of empty wagons increases to 2 tons of tare; or 56 tare to 44 net=56 per cent. of gross load.

Mr. Morton, of Fellows, Morton & Co., railway and canal carriers, of

* This proportion more accurately stated is 55 tare, 45 net.

Wolverhampton, in 1883 testified that his firm owned railway wagons (freight cars) as well as canal boats. The railway wagons and the boats were both employed in carrying limestone and ironstone. They find, he said, that going to and fro, loading and unloading, the wagons and the boats average about the same time. This would of course not apply to such distances as are found in the United States, but it tends to show how crowded traffic and the consequent delay in handling may neutralize the advantages of mere quickness of transit while the load is actually in movement.

The times of delivery by canal are said by Mr. Abernethy to be as easily regulated as by railway. Mr. Bartholomew in 1872 gave it as his opinion that with proper depth and supply of water inland canals could undoubtedly compete with railroads. Railroads might crush out a local canal by averaging rates over its whole system, but not so where the canal could give long route and through rates. Mr. Bartholomew said that in the season of 1872 the Northeastern Railway, at Hull, was as much as three weeks in arrears with their traffic; the Aire and Calder were two weeks behind. Goods, said Mr. Bartholomew, received by Aire and Calder at 6 p. m. at Leeds, were delivered in Hull at 11 a. m. next day; not unfrequently before the railway.

In 1883 Mr. E. J. Lloyd stated that no uniform principle in valuation of canals for taxation obtained in England; some were valued at value of adjacent land, area of water being taken like a similar area of arable land, or of house property, or otherwise; some as agricultural land only, and some were rated on their revenue. Some were even said to be not rated at all, and to pay no taxes. Witness's own canal was rated partly on revenue and partly as land.

IRRIGATING CANALS.

With regard to the use of irrigating canals, in this district it may be said that there are none in existence here; and, moreover, that there is no occasion for their employment. The tendency of the climate is towards too much moisture, rather than too little.

CONCLUDING REMARKS.

In conclusion, glancing briefly by way of review at the conditions described in the preceding pages, and, unsatisfactory as the facts set forth may be in respect of completeness, and system, and accuracy, they may still be taken to reasonably warrant certain deductions.

The inception of British canal building was purely local in its character; the enterprises were entered on separately and independently. There seems to have been little or no thought on the part of the first designers of the possibility, still less of the necessity, of ultimate combination and coalition. Hence the enormous variation in all the details of dimensions, direction, and general construction, and the resulting difficulty of mutual action when development demanded it at their hands.

Then came the glamour of steam railways. The imagination of the community was excited; and that which stimulated the progress of the railroad would appear to have unnerved and narcotized the energies which until then had shown such force in the establishment of canals—practically indeed having done previously to that time all which has been done at all.

The succeeding partial entry of the railway companies upon the canal

domain and the acquirement by these companies of the ownership or control of short lines of canals, detached and intervening links of longer routes, was followed by a natural consequence. Railway administration, which neither sentimentally had, nor practically conceived it to their interest to have, a bond of common feeling with the canals, worked for its own hand, nor does it sound unlikely when witnesses testify that something more than passive non-coöperation was adopted as a plan of action by some, if not all, of the railway companies which had become participants in the canal scheme of the kingdom.

From this state of things has come about "a decreasing leg," as was charged against the honest Falstaff in his declining years, and while the lack of going power on the part of the canals has perhaps not been accompanied to the same extent by the attribute next in order assigned to the good knight's list of defects, and their alimementiveness has not sufficed to altogether devour their substance, it must be acknowledged that, as a whole, the canal system of Great Britain has of late years been in a rather lamentable keeping.

That this condition is a necessary one the facts do not seem to establish. Ill-advised construction, divided management, and lack of intelligent energy will sufficiently account for the present status. The signs point to a change, and a change largely and decidedly for the better.

F. H. WIGFALL,
Consul.

UNITED STATES CONSULATE,
Leeds, February 14, 1890.

FALMOUTH.

REPORT BY CONSUL FOX.

The only canal at present in use in this country is situated in the extreme northeastern part of Cornwall, and is known as the Bude Canal.

It was constructed about 70 years ago, at a cost of about \$630,000, and extends inland for upwards of 36 miles. The barges are raised or lowered to the roadway by means of an endless chain, worked by water-power, and lifting it about a height of 120 feet perpendicular.

The canal belongs to a private company, and does not compete with the railway, as the latter does not run in the direction that the canal traverses.

HOWARD FOX,
Consul.

UNITED STATES CONSULATE,
Falmouth, September 3, 1889.

LIVERPOOL.

REPORT BY CONSUL SHERMAN.

THE LIVERPOOL CANALS.

The principal canals in this vicinity are the Shropshire Union Canals, made up of several canals, as stated below; the Leeds and Liverpool Canal, and the Manchester Ship Canal, formerly the Bridgewater Canal.

Originally they were built generally with sloping sides, but more recently the sides are perpendicular, and the towpath side is protected by granite wall, the other side being simply earth, protected in spots where necessary by piling.

The locks are chiefly of stone and brick, but latterly concrete is preferred for this. The lock gates are of elm, oak, or teak wood.

The Shropshire Union Canals afford the shortest and best canal route between the Mersey and South Staffordshire and Birmingham iron districts, and the only water route between that river and Shropshire and North Wales, Cheshire, and Chester. They also join the North Stafford Canal at Middlewich, and thus provide water communication between the Shropshire Union system and North and South Staffordshire, and also Warrington and Manchester districts. (See map attached, A.)

(a) Chester Canal, between the river Dee at Chester and Nantwich, a distance of 20 miles, the statutory authority for which was given in 1772.

(b) The Ellesmere Canal, from Carreghofa in Montgomeryshire, where it joins the Montgomeryshire Canal, to Hurleston in Cheshire, where it joins the Chester Canal, with a branch from the Dee at Chester to the River Mersey at Ellesmere Port, the act of Parliament being granted in 1793, the distance traversed covers 86 miles.

(c) The Birmingham and Liverpool Canal, from Autherly, a point of junction with the Stafford and Worcester Canal near Wolverhampton, to Nantwich, where it joins the Chester Canal, with a branch to the Shrewsbury Canal at Norbury Junction. Authority for construction given in 1826; the distance covered being 53 miles.

(d) The Montgomeryshire Canals, from Correghofa (where the Ellesmere Canal begins) to Newtown in Montgomeryshire, with branches.

The authority for this was given in 1794. The distance covered is 25 miles.

(e) The Shrewsbury Canal, from Wombridge to Shrewsbury in Shropshire, the authority for which was granted in 1793; the distance covered being 22 miles.

The whole of these canals were formed into the Shropshire Union Company in the year 1846.

The total length of the various canals forming the company's system is about 206 miles.

The canal from Nantwich to Ellesmere Port (its terminus), where it joins the river Mersey, is sufficient to pass lighters and flats carrying from 40 to 60 tons, and such craft are constantly employed upon it.

On other parts of the system narrow boats 7 feet wide are used, which carry from 18 to 30 tons, according to the depth of water. The depth of water varies from 3 feet to 4 feet 6 inches.

The locks on the canal from Chester up to Nantwich are broad and admit two narrow boats at a time. On other lengths they are narrow.

In all districts the width of the water way is sufficient to admit of two narrow boats passing at the same time, except through the locks, tunnels, and aqueducts.

THE TRAFFIC.

The canal between Chester and Nantwich was intended for the conveyance of coals and general merchandise to what was at that time the second principal town in Cheshire, and for bringing down salt and other commodities to Chester for shipment on the river Dee. There is still a connection with the river Dee, but the traffic between these points is

now extremely small, as the canal serves as part of the through system between South Staffordshire and the river Mersey.

On this through line, in addition to the local traffic, part of the important iron industries and hardware goods of South Staffordshire are brought down to the company's port on the river Mersey, and put into vessels there or conveyed to Liverpool for shipment to other countries.

The imported traffic consists of foreign timber, grain, and general merchandise for inland consumption; also large quantities of iron ore and pig-iron brought into Ellesmere Port by coasting vessels, and clay and flints from the west of England and France for the manufacture of earthenware in the potteries.

A large traffic is also conveyed between the North Staffordshire potteries and Liverpool, excellent storage accommodation being provided by the company at Stoke-on-Trent, Etruria, Hanley, Burslem, Longport, Longton, and Tunstall, where goods can be received from the manufacturers, as they are packed and stored free of charge.

Any earthenware or china intrusted to the care of the company is covered by fire insurance from the time it is handed to their teams until it is delivered alongside ship in the Liverpool docks, and every care is exercised in dealing with consignments handed to them.

The company's depot on the Mersey is at Ellesmere Port (situate 9 miles from Liverpool), where they also have very large warehouse accommodation, fitted up with all the most modern appliances for dealing with crates of earthenware, china, and other traffic.

The Shropshire Union Company have a large fleet of boats working between the pottery towns and Ellesmere Port. Special express boats leave daily, and every dispatch is given to the traffic. They also have steamers plying every tide between Ellesmere Port and Liverpool for the delivery of goods alongside ships in the Liverpool Corporation Docks.

The Company's fleet consists of 3 river steamers, 7 canal steam tugs, 116 flats and floats, and upwards of 400 canal boats.

The tugs are of three classes, viz:

River steamers plying on the river Mersey between Ellesmere Port, Liverpool, and Birkenhead, which tow the barges and vessels, and also carry passengers. They are twin-screw boats and have on board the latest type of machinery.

Canal tugs.—These are small screw boats, and are employed in towing barges between Chester and Ellesmere Port.

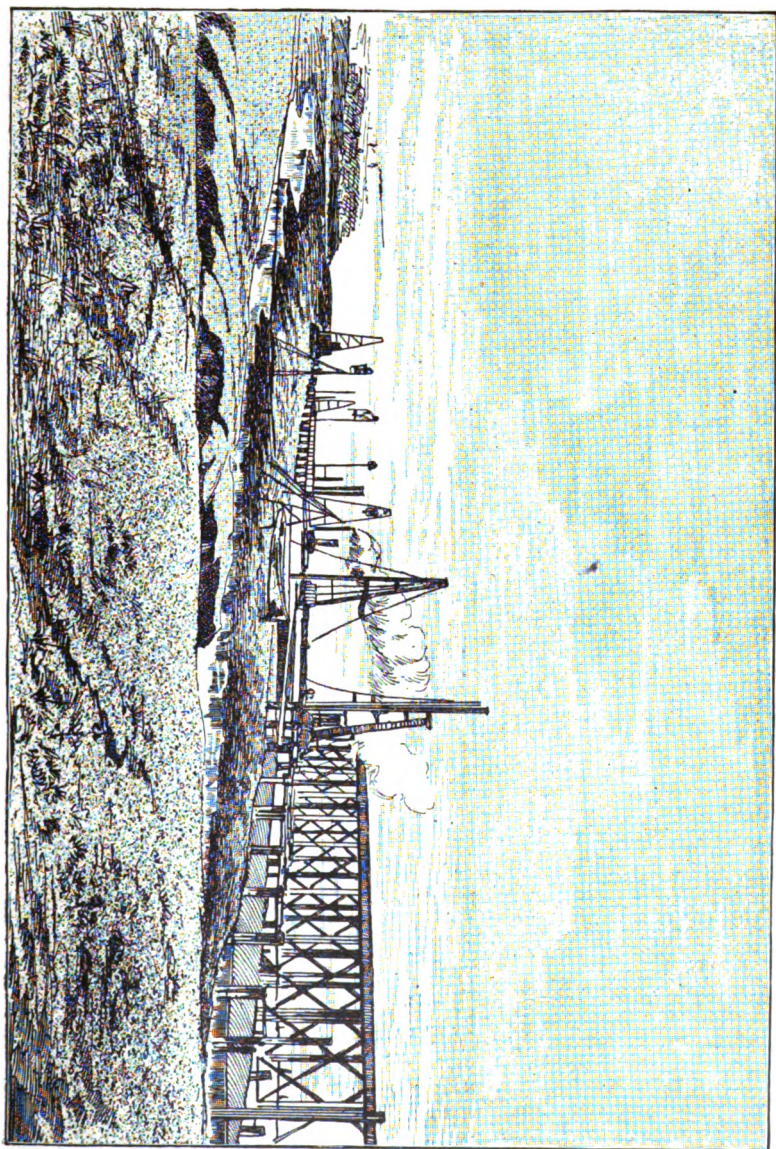
Cargo tugs.—These are likewise small screw boats, and work between Ellesmere Port and Wolverhampton; they themselves carry cargo, in addition to towing three or four of the ordinary boats.

The larger portion of the company's boats are hauled by horses. In some districts the steerers provide their own cattle, but the bulk of the horses belong to the company.

The canal from Montgomeryshire, which joins the through line at Hurleston, had originally a very large local traffic in lime, coals, stone, and timber. This has been interfered with by the railway, which has been constructed, and in many places runs alongside.

There is now a considerable grocery and grain traffic thereon from Liverpool, also lime and stone for South Staffordshire, in addition to the traffic conveyed by local traders.

Up to the year 1842 the traffic was carried entirely by traders, who paid "toll" according to the rates fixed by the various acts of Parliament. Since that time the company have become general carriers, and the greater portion of the traffic is now carried by them.



AN EMBANKMENT ON THE MERSEY.

GENERAL MANAGEMENT.

The maintenance and efficiency of the canal is intrusted to a paid engineer, who, with his assistants, called district inspectors, and a large staff of bank-tenders, workmen, and laborers, are responsible for the maintenance and safety of the banks, locks, and other works and the supply of water.

The engineer is directly responsible to the board for his duties.

The traffic department is managed by a large staff of officers. In each town of importance the company has an agent, whose duty it is to see that a share of the traffic in the neighborhood is obtained for the company, to see to the loading and unloading of boats, delivery of goods, collection of accounts, etc.

In the larger towns the duties of canvassing for traffic, collection of accounts, and other duties are separated, and given to an individual officer.

The whole work is presided over by a general manager, to whom each agent reports from time to time, and who is directly responsible to the board for the whole management of the traffic.

The following is a copy of the specification for the construction of the Birmingham and Liverpool Canals:

The breadth of the canal at the bottom to be 16 feet and at the level of the top of the towing path 40 feet, the depth of water 5 feet, the height of the towing path and top of the opposite bank 1 foot above the water's surface, the breadth of the towing path in all cases except at bridges and also that of the opposite bank, where above the level of the natural ground, to be 10 feet, the inner slopes of the canal from the level of the towing path downwards to be at the rate of two horizontal to one perpendicular, and all other slopes to be at the rate of one and a half horizontal to one perpendicular.

The side puddles are in all cases to be 3 feet in thickness, and the bottom puddle or lining (where required) is to be half a yard in thickness, excepting on embankment exceeding 8 feet in height, where it is to be 2 feet thick and covered with 6 inches in depth of gravel or soil.

In executing the sundry cuttings and embankments the former must be run to the latter, so as to do away, as much as practicable, with the necessity of side or back cutting, and no side or back cutting is to be allowed, unless the distance to remove the earth from one part of the canal line to the other shall exceed 600 yards, in which case side cutting will be allowed.

In all cases of side or back cutting the vegetable soil must first be stripped off and laid aside in some convenient place, and the earth under it be removed in such a manner that the lowered surface may be left in a regular cultivable shape nowhere steeper than six horizontal to one perpendicular, and so that rain or other water may get readily off. The vegetable soil previously removed must afterwards be spread evenly over the lowered surface of the field.

In places where there is more earth in the cuttings than is required in the adjoining embankments, the contractors may lay it out on each or either side of the canal as spoil banks, so as to cause no unnecessary damage, and it must be leveled or sloped so as not to be steeper than six horizontal to one perpendicular.

In cases of common cutting in retentive soil the vegetable surface of the part to be excavated shall be removed to the outside of the slopes of the banks, that the quicks may afterwards be planted therein, and the remainder of the excavation is to make good the remainder of the banks. The side puddles shall be in the middle of the banks, brought up from a level of 18 inches below the natural surface of the ground to 6 inches above the level of top water in the canal. There must also be back ditches where necessary to lead the water from the surface of the land to the nearest culverts or natural water courses. The dimensions, etc., to be agreeable to the transverse section No. 1.

In common cutting, where lining is required, the excavation must be as much greater in the first instance as will allow of the side and bottom puddle being put in and afterwards protected by gravel or earth, as shown by the transverse section No. 2.

Where there is extra embankment of 10 feet or upwards in height the bottom and side puddles are to be put in, as shown by the transverse section No. 3.

Where the extra embankment does not exceed 10 feet in height, and the natural soil is retentive of water, the contractor may put in either bottom and side puddles,

as shown by the transverse section No. 3, or he may bring up vertical side puddles only as shown by the transverse section No. 4.

Where there is extra cutting in retentive soil the cutting must be sloped up from the field side of the towing path on one side and from the back of the benching on the opposite or off side of the canal, as shown by the transverse section No. 5.

When there is extra cutting, where lining is required, the earth must be sloped as last described on the towing path side, but a benching of 4 feet wide must be made at the level of top bank on the off side of the canal in order to get in the side lining or puddle, as shown as by the transverse section No. 6.

In all embankments where a bottom lining or puddle is laid on, the earth below must be first leveled and consolidated for the full breadth of the canal and its bank, the puddle is then to be laid on and properly worked, and afterwards protected by 6 inches of soil or gravel, as shown by the transverse sections. The side puddles are then to be carried up to within 6 inches of top bank level. They are to be 3 feet in thickness.

All puddles are to be composed of a proper mixture of clay and gravel, they must be thoroughly worked in courses not exceeding 6 inches each, so as to be, when finished, perfectly water-tight.

In all changes of the transverse section, the different descriptions of puddles must be perfectly connected. The contractor is not to sublet the working of the puddles separately from the rest of the earthwork.

In all embankments to bridges, where the rates of inclination are not separately stated, the ascent of the roads are in no case to be steeper than one in thirteen, and for all turnpike roads they must not be steeper than one in twenty.

The breadth of these embankments at the level of the roadway is to be 30 feet for turnpike roads, 20 feet for other public carriage roads, and 12 feet for accommodation roads.

The earth backing to bridges, culverts, and other masonry and brickwork (not otherwise herein specified) is to be firmly punned to the walls for at least 2 feet in thickness.

Where bridges cross the canal or where locks are entered, the breadth of the canal shall be gradually diminished in the last 60 yards to the width between the wing walls of such locks or bridges.

Water-way walls.—Water-way walls are often constructed to protect the edges of the towing path from injury by the wash of the water where there is much traffic. These walls generally extend from 2 feet below top water to 1 foot above the same level, as shown.

Waste weirs.—Self-acting waste weirs are constructed at convenient points (usually near a water course), in order that surplus water due to floods may at once run off and relieve the pressure upon the canal banks. The weirs are constructed with their tops flush with top water in canal.

Let-offs.—In order that the water may be drained from any part of the canal for repairs or cleansing let-offs or sluice-valves which can be opened and closed when required are provided at short intervals.

Stops.—At points where the width of the canal is contracted, such as bridgeways and locks, grooves are built into the water-way walls to receive stop planks in order to divide the canal into short lengths, and thus avoid the necessity of running out a long level for the purpose of local repairs. The stops are also used to confine the effects of a breach to a short length.

In high embankments stop-gates are fixed so that in the event of a breach taking place the flow of the water will close the gates and cut off the other parts of the canal.

TOWING PATH.

The towing path is formed with a slight slope downwards from the side of the canal for the purpose of drainage; there is a drain at the back and cross drains discharging into the canal at intervals. The surface of the towing-path is covered with raffil (limestone débris), furnace cinders, etc.,

LOCKS.

The locks are constructed of brickwork or masonry. In one case at Beeston on the Chester Canal, where the site of the lock is a bed of quicksand, the sides and floor are composed of cast-iron flanged plates bolted together and supported upon piles; the sides are tied and stayed to piles driven down at the back.

The dimensions of the locks vary considerably, but the locks to take boats of 7 feet beam were designed as follows: Minimum width, 7 feet 6 inches; length (between hanging posts of gates), 82 feet.

The working length is less than this, but will admit boats about 72 feet long over the tiller. The fall or difference in level between the upper and lower levels of the canal varies from 6 to 8 feet.

The minimum working dimensions of the wide locks to admit boats of 13½ feet beam plying between Ellesmere Port and Nantwich are, width, 13 feet 10 inches; length, 75 feet.

LOCK GATES.

The lock gates are now constructed of oak timber; the upper gates are usually single, framed and sheeted; the lower gates are hung in pairs and meet at an angle pointing towards the upper level. These are constructed of solid timbers bolted together; they are opened and closed by the aid of balance beams or long levers. Many of the lock gates have been constructed of cast-iron.

Inclined plane.—There is an inclined plane on the Shrewsbury Canal, at Trench, for transferring boats from one level to another. The boats, which carry loads of 5 tons, are floated over a cradle and drawn upon a railway by a steel rope passing round a pulley at the top; the loaded boats descending draw up the empty boats. There is an engine for drawing the cradle from the upper level on to the incline. The incline is 230 yards long and rises 73½ feet.

CONSTRUCTION.

So long a period having elapsed since the formation of the canals comprised under the Shropshire Union System that it is difficult to state with any degree of accuracy the length of time actually occupied in their construction. And the same will apply to other canals.

Chester Canal.—The act authorizing the construction of the canal between Chester and Nantwich received the royal assent upon April 1, 1772, and the canal was completed in 1776.

Ellesmere Canal.—Operations were commenced in 1793. The canal between Chester and Ellesmere Port was completed in 1795. The canal between Chirk and Llanymynech and Weston was completed about the year 1797, and the whole of the canals comprised under this head, with the exception of the Whitchurch branch, were completed in 1805 or 1806. The Whitchurch branch was made in the years 1810 and 1811.

Birmingham and Liverpool Canal.—Commenced in 1828 and completed in 1834 or 1835.

The Montgomeryshire Canals.—The eastern branch, from Carreghofa to Garthmyl, was commenced about the year 1794 and completed about 1816. The western branch, from Garthmyl to Newtown, was commenced in 1815 and completed about 1820.

Shrewsbury Canal.—The Shrewsbury Canal, between Shrewsbury and Trench, was commenced about the year 1793 and completed about 1797.

A short length of this canal, between Trench and Dormington, was in existence prior to the above dates.

Middlewich Branch.—The canal from the Ellesmere Canal at Barbridge near Nantwich to the Trent and Mersey Canal at Middlewich was commenced in 1827 and completed about 1833.

The Leeds and Liverpool Canal was constructed under powers obtained by various acts of Parliament, the first being obtained in 1768. Under these acts the main line from Leeds to a point nearly 8 miles west of Blackburn and from Wigan to Liverpool was constructed. The connecting link of $10\frac{1}{4}$ miles between Wigan and the point west of Blackburn where the main line was stopped was completed by the Lancaster Canal Company and is now leased by the Leeds and Liverpool Canal.

MISCELLANEOUS STATISTICS.

The maximum rates of toll to be charged are fixed by the various acts.

In addition to the acts for the construction of the main line special acts have been obtained for the purchase of the lower Douglas Navigation and also for the construction of a branch from Wigan to Leigh.

The canal from Liverpool proceeds in an easterly direction to Wigan and then in a northerly direction through Blackburn, Church, and Burnley on to Skipton, after which it goes in a southeasterly direction through Bingley to Leeds.

The summit pool is 487.5 feet above the ordnance datum.

The first canal act was, as I have stated, obtained in 1768, and the canal was opened throughout in 1815. The locks on the canal are of sufficient size to allow boats 60 feet 6 inches long and 14 feet 6 inches broad to pass.

The weight of traffic which passed over the navigation during the year 1889 was upwards of 2,500,000 tons.

The total length of the main line of canal is 128 miles, the branches are 13 miles, making a total of 141 miles.

In some cases canal companies do not own the boats plying thereon; they keep the canals in repair and are merely toll takers.

In others the companies own the entire fleet and control their whole system of traffic. Some canals are owned by railway companies who place the tolls so high as practically to drive all traffic to the roads.

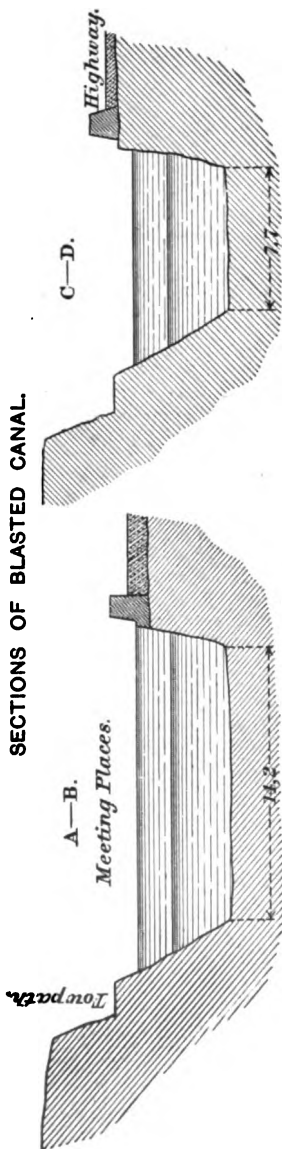
CANALS VS. RAILWAYS.

The construction of canals in the days of their early history and before the introduction of railways materially led to a considerable cheapening of the price of transportation compared with the old days of carriers by wagons along the high road, and between places not served by a railway the cost of conveyance and quickness of dispatch by canal is now immeasurably superior to that by road.

The effect on canals serving distant towns by the introduction of railways has been very prejudicial owing to the railways being able to perform quicker deliveries. But between towns not so distant, or when time allows of as quick a delivery as railways, and when the traffic to be conveyed is sufficient to pay a return for the cost of constructing and maintaining two modes of conveyance, the canals are able to act as a formidable competitor to them, and take their part in cheapening the cost of transportation.

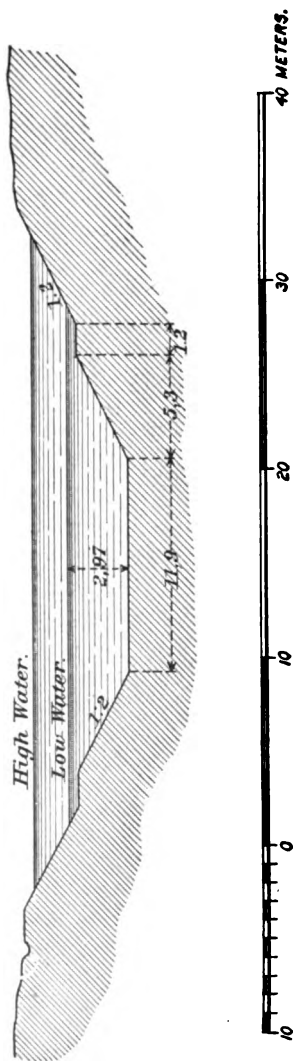
There is no doubt that canals have exercised a powerful influence not

SECTIONS OF BLASTED CANAL.



SECTION OF DUG CANAL.

E-F.



only in preventing the railway companies from charging much higher rates but in cheapening transportation generally over their routes. It is quite impossible, however, to give the figures to show this.

Irrigating canals are not necessary in this district.

I append some interesting articles from the Liverpool Post, newspaper, on the great ship canal now in course of construction between Liverpool and Manchester.

THOS. H. SHERMAN,
Consul.

UNITED STATES CONSULATE,
Liverpool, February 25, 1890.

[First article.]

MANCHESTER SHIP CANAL.

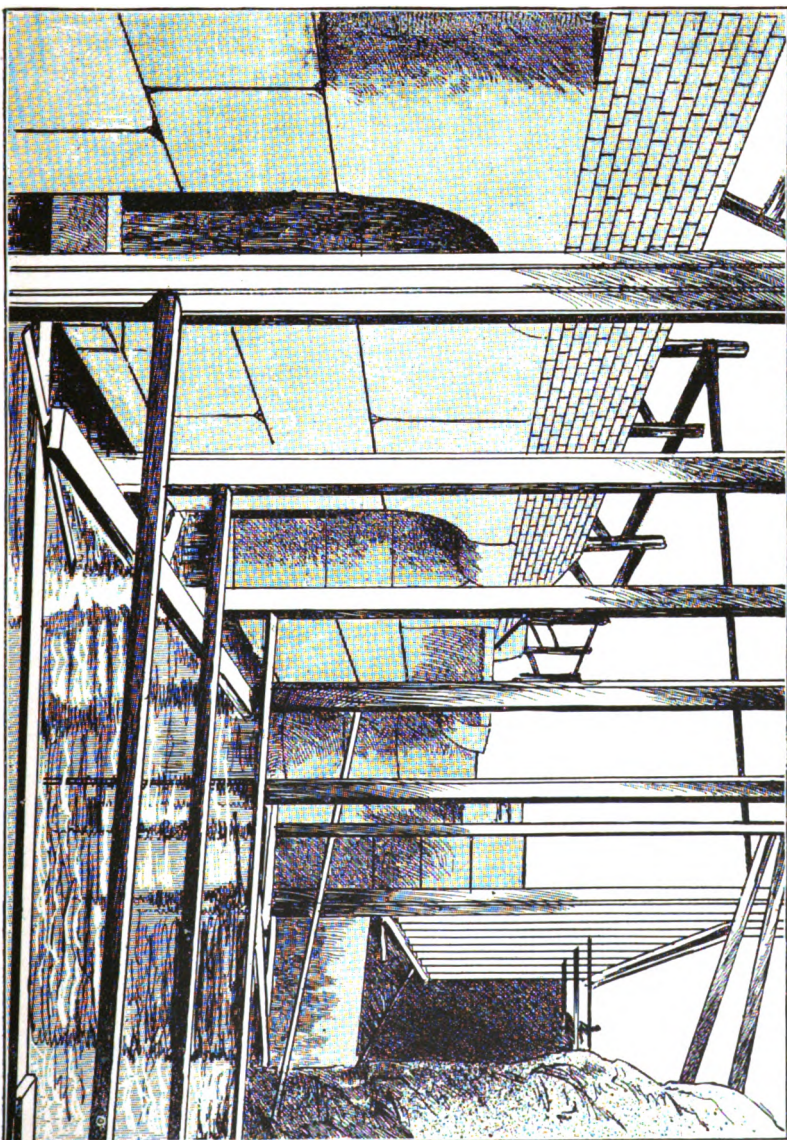
At this time, the opening of the new year, it will doubtless be of interest to our readers to learn what progress has been made with the Manchester Ship Canal, so that as the year wears on the further growth of the work may be marked. The section nearest to Liverpool, and therefore of the most interest locally, is the Eastham section, extending almost in a straight line from that place to Ellesmere Port, where the Ince section begins. In one sense the Eastham division is the most important of the entire system, as here are the great locks dividing the canal from the river, whence it is hoped by the promoters the ships will enter and proceed up to Manchester. The locks here are larger than anywhere else on the canal, and their construction, together with the building of the culverts, sluices, and gates, are the most interesting, as they are one of the most expensive bits of work throughout the system. The amount of material employed is something stupendous, and no idea of the canal's vastness can be conveyed by mere figures. For instance, if we say that the cutting where the locks are in course of erection is over 100 yards across and nearly 70 feet deep, a very bald idea is conveyed; an idea, however, which may be more strongly conveyed by the statement that there are probably not a score of cricketers in the kingdom who could throw a ball from bank to bank. The statement that 3,000,000 cubic yards of clay and soft material and 750,000 cubic yards of rock have been excavated is very imposing, but just as confusing as is the further statement that 6,000,000 tons of material have altogether been excavated between Eastham and Ellesmere Port. But properly to appreciate the greatness of the work it must be seen, with the laborers crawling about away at the bottom of the canal, the steam diggers clanking and tearing savagely at the earth, the locomotives puffing up steep gradients, the cranes noisily hauling great blocks of red sandstone to mid-air, and all seemingly at a level far below the ordinary surface.

THE NEW EASTHAM.

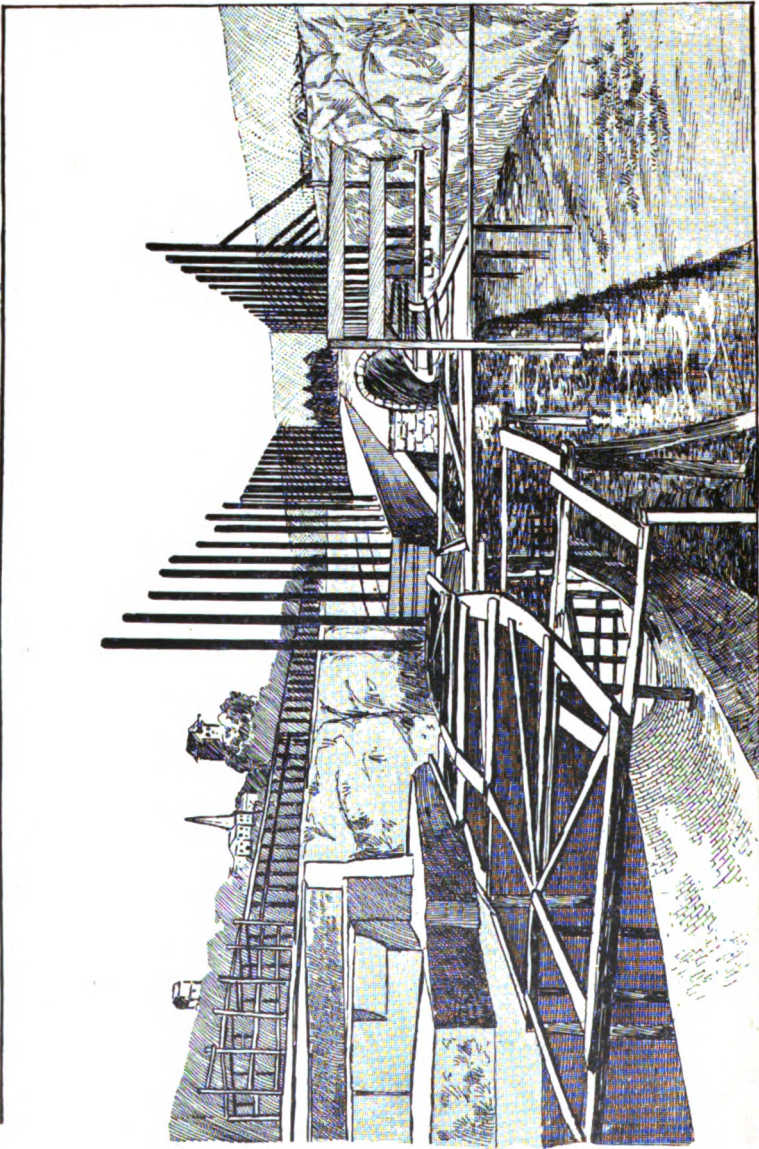
The earth excavated from the enormous cutting has been run along in a line with the landward bank of the canal, beyond the entrance gates, and the line of shore has been pushed seaward as the bank has grown, until the river itself has been so encroached on that cement-laden flats and other small vessels are now able to run along-side and discharge their cargo at the artificial bank. The one-time glories of "Aunt Sally" and archery have given place to the greater glories of engineering. Where once whirled the "three sticks a penny," great blocks of granite now repose, and the twang of the bow-string is supplanted by the rattle of cranes and the shriek of the locomotive. Beyond Eastham, the long grassy plateau whereon the Cheshire engineers were wont to hold their annual camp now holds a more permanent encampment of workmen, a double row of whose wooden sheds form quite a lengthy street. The houses, generally speaking, are very tidily kept, some of them even displaying evidences of the most careful tidiness, neat little curtains, flowers, and plants embellishing the windows. Many of the houses have quite a stock of fowls, from which the goodman or goodwife probably reaps substantial benefit. From the Eastham road down to the canal itself all sorts of sheds have been erected for the convenience of the men and the necessities of the work—cement sheds, joinery shops, engineering sheds, and, largest of all, the great wooden building wherein the lock gates are being put together. Among the smaller buildings are the offices of the agent, Mr. E. Manisty, who has the entire charge and control of the work on the Eastham section. The men-

tal and spiritual needs of the men are well looked to, for among the better class buildings a comfortable chapel rears its itself, the place being seated for about 400 persons; and reading-rooms, where night classes are held, have been put up by the managers, who have, indeed, done all that is possible for the comfort and well being of the men under their charge. For those inclined to take their pleasure more robustly, a football club has been formed, and a capital team they turn out, too, the ground being an excellent one. From these brief particulars, it may be seen that a well-behaved workman on the Manchester Ship Canal has anything but a hard time of it. Turning from the men to the works, the first thing to strike those familiar with the old Eastham is the change of shore line, to which we have already alluded, the long level of red earth running right into the river, just to the south of the stage, being certainly an improvement upon the black muddy shore which nature's forces had maintained until a couple of years ago. This bank, as it runs landward, gradually slopes from the river, and at the lock gates it forms the inner bank of the canal, the distance from the low-water mark being something over 120 yards. The outer bank here will be situated almost where the present natural high-water mark is shown by a line of sticks, corks, and general rubble washed up by the waves. From this it will be understood that the canal debouches into the river at an angle to it, and at its mouth the locks will be, roughly speaking, at an angle of 45 degrees, the biggest lock of the three being nearest the land, and the smallest being nearest the river and the farthest from Eastham ferry. The west bank thus runs out beyond the gates to the distance of 300 yards, and its entire surface will be dressed with trimmed red sandstone upon a backing of dry rubble; this protection being so fixed as to form a surface calculated to resist the action of the waves which during certain winds will be dashed upon it from the river. As the present depth of water would be quite inadequate for the requirements of the canal company, a channel will be dredged from the lock gates out seawards, joining the deep water of the river. The probability of this channel silting up has been foreseen by the promoters, and to meet the difficulty dredgers will periodically clear the way, and, of course, a further preventative of silting is furnished in the sluices, from which a great volume of water will rush when the level of the lock is being lowered. Walking from the ferry along the inner bank of the canal, we come to the locks, which are now in course of construction, but as the outermost portion of the canal proper will be the lock gates, we shall first devote our attention to them, prefacing their description with the remark that there are three locks, the entrances to which are 80 feet, 50 feet, and 30 feet in width, respectively.

The gates are of themselves no slight undertaking, and we are not surprised to learn from Mr. Lawson, foreman of the gatehouse, that, including the sawyers and the laborers engaged in getting in the timber, about three score men are engaged on their construction. At the entrance to each lock there are two pairs of gates—storm gates and inner gates—and at the top of each lock there is another pair. The two lower pairs at each lock are of equal strength, but the storm gates open seawards, in which direction they are convex, and the inner open inwards, they being convex in that direction, so that each pair is constructed with greater resisting power towards the greater strain. The outer gates, however, may not be used once in a twelvemonth, but it was thought safe to provide them for the protection of the inner in case of rough weather; also, they may be used should it be necessary to repair those which will be ordinarily in use. The 80-foot gates are enormous affairs, each leaf of the two lower pairs weighing no less than 260 tons, making a total for the storm and inner gates of 1,040 tons. They are built of the finest solid greenheart, a wood particularly suited for such constructions, both by reason of its nonshrinking characteristics and its wonderful solidity. The remarkable closeness of the texture of greenheart wood may be comprehended from the fact that a block of the material measuring 3 feet 3 inches square weighs a ton. In describing the gates, it must be understood that each pair, as we have stated, consists of two leaves, and the four leaves of the lower gates are all of precisely similar construction. As the 80-foot gates are the most imposing, we shall utilize them for description. Every leaf is built in three sections divided by and firmly mortised to enormous beams running the full depth of 45 feet 5 inches from top to bottom of the gate. At the bottom, where the pressure is strongest, the greatest strength is given, and as the gate rises it is lightened by spaces being left between the lateral beams, these gaps being boarded over with strong planking. From the outer to the inner post, or from the miter post to heel post, as it is technically phrased, the main beams are so arranged that a curve is made, as of a bent bow, but this is filled in with balks and planking, the width in the center of the bow being 5 feet, while at either end it is of the same thickness as the posts. Beginning at the bottom and working upwards, there come in each section twelve solid greenheart beams, 12 feet 8 inches long and 16 inches square; then comes a space of 16 inches; then follow three ribs of 15 inches each, space of 13 inches; three ribs of 13 inches, space of 2 feet 3 inches; two ribs of 15 inches, space of 2 feet 6 inches; two ribs of 12 inches, space 3 feet 6 inches; one rib 16 inches, space 4 feet 3 inches; and the top rib of 15 inches. At either end these are all firmly mor-



THE SLUICE BELOW THE CANAL, BOTTOM LEVEL.



EASTHAM LOCKS, IN PROGRESS OF CONSTRUCTION.

tised into the great perpendicular beams 2 feet 4½ inches square, and the inner section is similarly made fast to the heel post, while the outer section is affixed to the miter post.

As will be seen from the figures given, the total height of the gate is 45 feet 5 inches, but the heel post is 48 feet 3 inches, the extra length being required that the head and the foot may be so fixed as to permit of turning. The heel is shod with steel, and will work upon a steel pivot, while the head will be buried in the masonry, in which a steel collar will encircle it. The heel posts are ponderous pieces of wood, each being a solid beam of 6 tons 5 cwt., while the miter posts weigh 6 tons 15 cwt., and the section posts—each of which consists of four beams 14½ inches square—weigh each 10 tons 15 cwt. From the top of the heel post to the foot of the miter post there is a steel strap, 8 inches wide by 1½ inches thick, running across the gate diagonally, and this may be adjusted to various tensions, bracing the gate firmly, and it also will serve to equalize the weight to some extent, it being at the angle of the greatest strain, the continuance of which strain in such a massive work might easily result in the warping of the whole structure. The gates will be worked by hydraulic pressure, the outside posts running upon a metal race way 2 feet in width, there being a steel wheel 1 foot 11 inches broad set in the foot of the post. This wheel has roller bearings something similar to the ball bearings of cycles, rollers running the length of the wheel being substituted for balls, and with the further difference that the rollers are inside the wheel, but do not come as far as the real bearings, so that it will be necessary, if the rollers are to bear any of the weight, that the bearings should be cut materially larger than the pin on which the wheel works, otherwise the strain would remain on the bearings at the outside of the hub, and the steel rollers would be useless.

One would think that the exceptional strength of the gates was sufficient for all possible contingencies, but to make assurance doubly sure, vertical fenders are run down the front of all the outer gates, those for the largest being greenheart beams 12 inches by 9 inches, and for the 50-foot and 30-foot locks beams of 12 inches by 6 inches. The entire structure is bolted together with vertical cess bolts of 1½ inches and 1¼ inches in diameter. The 50-foot and 30-foot storm and lower gates are of the same height as those already described, but at the upper end of the locks all the gates are 10 feet 9 inches less in height, the water in the locks being 36 feet 9 inches deep, while the general depth of the canal above the locks is only 26 feet, and therefore smaller gates can be made to serve. In thickness the 50-foot gates are 3 feet, and the 30-foot gates are 2 feet 2½ inches. Across the top of the lower gates a footway will be constructed for the convenience of those needing to cross the canal at the point. In the gate-house much progress has been made with the work, one pair of 80-foot gates being finished, also one pair of the 30-foot and one pair of the 50-foot gates are rapidly approaching completion. When ready the gates are put together in the shed, to be afterwards taken apart in sections and fixed in their permanent positions. Along the sides of the shed a trolley-way, about 12 feet from the ground, has been erected, upon which runs the large crane used for moving the weighty logs about, and after dark the place is lighted by electricity. Some of the wood being worked shows splendid grain, and is of a rich dark color, resembling olive and other ornamental woods. The chips from the shed and the dust from the sawpits where the logs are roughed out are utilized for laying on the roads, and they are said to make a better and cleaner road than any other similar material.

[Second article.]

PROGRESS OF THE CANAL.

The account given in our Thursday's columns of the progress already made in the construction of the Eastham section of the Manchester Ship Canal was devoted mainly to a description of the lock gates, and, following our plan of working landwards, this article will treat of the locks themselves. These are the main works on the Eastham section, and are, indeed, one of the principal works on the entire canal, being larger, stronger, and deeper than those more inland. The nearest locks after leaving Eastham are those at Latchford, 21 miles away, and of course it follows as a necessity that from Eastham to Latchford the level of the water is at one height, an advantage of having so long a section next to the river being that the tidal flow may be utilized to make up for water lost in working the locks. That is to say, that at spring tides the outer and inner gates may both be opened and the waters of the Mersey will flow in, raising the level of the canal surface right up to Latchford, thus making it in a small degree a tidal river. And this will doubtless prove of no little service, for every time the large lock is used for lowering a vessel into the river a vast quantity of water is taken from the canal to restore that in the lock to the level of the general system. There are three locks, of which the dimensions are as fol-

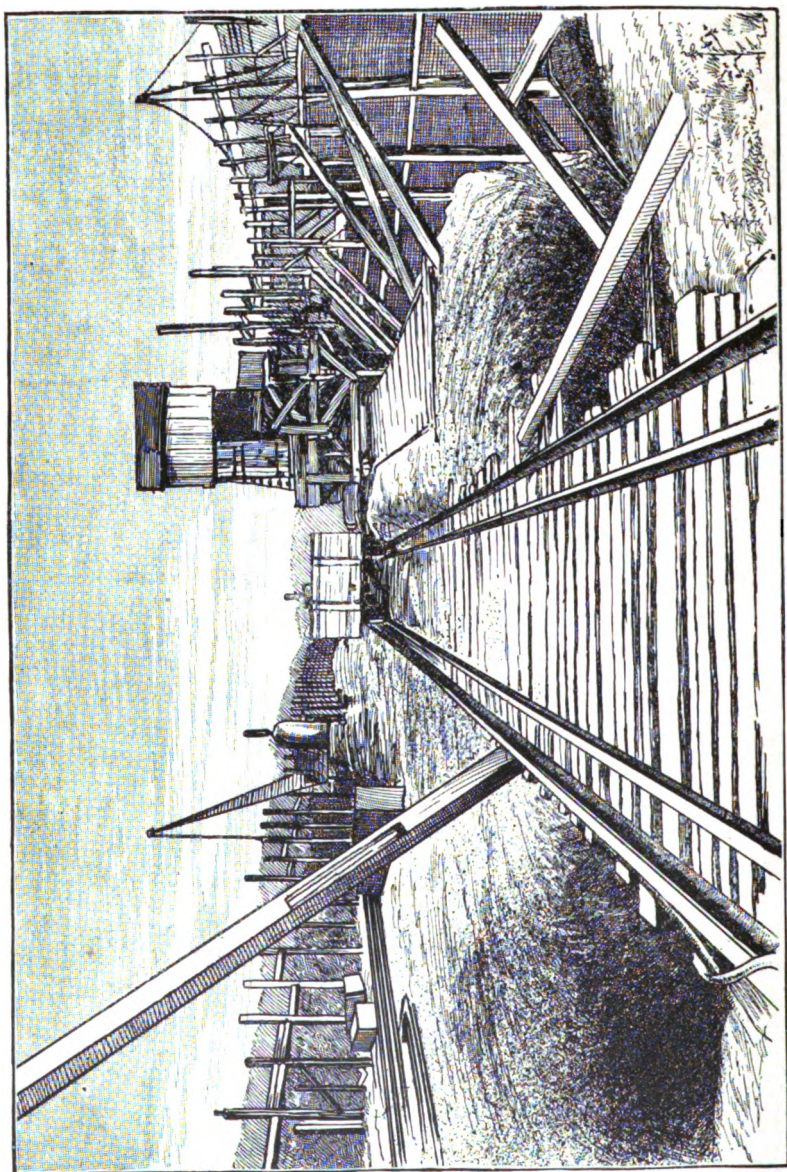
lows: No. 1 lock, 600 feet by 80 feet; No. 2, 350 feet by 50 feet; and No. 3, 150 feet by 30 feet; but, notwithstanding their great size, the locks do not by any means constitute the entire breadth of the cutting at that point. Firstly, there is on the landward side an arm of the canal running down the side of the large lock on the one hand and the great embankment of the canal on the other, the mouth being formed by a dam very slightly above the ordinary level of the water, which is 26 feet. This has been constructed in accordance with the demands of the Mersey authorities, who required that none of the tidal water should be retained in the canal, and by the method adopted of leaving this dam to act as an overflow when the water reaches a certain height ships may be passed in or out at the highest state of the tide. They may also be passed out when the tide has receded, and the overflow will continue till the proper level is reached. If there were no overflow the locks would be affected if closed just before the turn of the tide, and difficulty would be experienced for some little time in working the vessels in and out. The overflow raceway or arm is 59 feet wide; then comes the wall or platform dividing it from the large lock, the width of this platform being 35 feet 9 inches. On this, as on the other platforms, there will be ringbolts and other appliances necessary in manœuvring or making fast a vessel, and of course there will be the small houses containing the starting levers for the working of the locks, the motive power being hydraulic. Beyond this platform comes the lock, 80 feet; then the second platform, 30 feet; the 50-foot lock; third platform, 30 feet; small lock, 30 feet; and the outside embankment, 22 feet; making a total from the inner wall of the canal to the outer edge of the river wall of 336 feet 9 inches. The smaller locks will be used whenever possible, in order to economize the loss of water as much as practicable under the circumstances.

Although the system of working the locks is very simple, it is a difficult matter, perhaps, to explain it without many illustrations so as to be easily understood.

At the upper end and outside of the locks there are sluice-holes, from which culverts or large drains run, finding openings inside the locks; and at the lower end a similar system exists, the sluice opening into the river, and the culverts being formed inside the platforms dividing the locks. For the sake of illustration we may suppose that the captain of a vessel coming down the canal wishes to reach the river at a comparatively low state of tide, the water in the river being perhaps a fathom less in depth than the canal. The vessel having entered the lock the upper gates are shut, and then the sluice at the lower end is opened, which is done by a sliding door over the sluice mouth being lifted up. The lock water rushes through the culvert opening, along the culverts and out at the sluice, and in a few seconds the lock is on a level with the river, the sluice door is dropped, and the gates being opened the vessel reaches the river without any perturbation of the surface either of the lock or the Mersey. For vessels entering of course the process is reversed, and if the river be higher than the canal level the latter is raised before the vessel enters. The culverts in the large locks are immense holes, there being at each end four arched doorways, as they might be called, 6 feet high by 4 feet broad, and these open into a culvert or huge drain 12 feet high by 6 feet wide, both top and bottom being arched. The amount of water which can pass through such a culvert in a minute is something stupendous, and even the great lock can be lowered several feet in a space of time to be measured by seconds. The progress made in the construction of the lock has been very satisfactory, the greater amount of work having been put on the 80-foot lock, of which all the foundations are laid, and at the north end the walls have been built up to the height of about 21 feet. The upper and lower sills where the gates are fixed have been laid, the culverts are partially built, and both sluice and culvert openings are completed. Looking at the half-built culverts some idea can be had of the volume of water rushing out to lower the level in so brief a time as will be necessary. There is a solid foundation of concrete, on which is placed the bottom arch of the culvert, consisting of two courses of hard blue-clay bricks. The walls will be built up of similar material, and then the platforms between the locks will be filled in with concrete. As may be seen from the illustration of the exit sluices, all the arches are built up of granite, of which also the entire inner walls of the lock platforms are built, the intermediate spaces being of brick and concrete. In the second illustration the arch of the culvert may be seen in the middle distance, and in the center of the foreground the bottom of the culvert with its brick arching is shown, both the pictures being taken from the great lock. In the 10-foot lock the gate sills are laid and the culvert ways are in progress, while nearly all the foundations of the lock have been now laid, and the walls are well under way. The 30-foot lock has not been worked at so much, but the sills have been laid and some of the other foundations prepared. The outermost wall has not yet been started, as it, of course, must needs wait till the small lock has progressed more. At present work is being carried on very rapidly, although the men have to cease their labors at half past 4, beyond which hour the darkness prevents any outdoor work, although in the various sheds the men continue until half past 6, daylight being superseded by electric lamps.

Beyond the locks much progress has been made, and of this our next article will treat.

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THE CANAL CUTTING NEAR ELLSMERE PORT.

[Third article.]

PROGRESS OF THE CANAL.

Passing from the locks and gates, which we have described in our former articles on the Eastham section, we shall now take the general cutting of the canal up to Ellesmere Port, and in a walk to this latter place may be marked the great progress which has been made with the excavations. The land outside the locks has not yet been entirely cleared away, nor will it be till the latest possible hour, but the excavations have been extended much beyond the locks, leaving a massive wall of clay yet to be broken down before the river can reach the gates. The outside channel, too, is another work which will be left as long as possible undone, for the probability is that if it were carried out much before the canal was ready the channel would rapidly be choked by silting sand, of which the overflow and lock water will keep it clear when the canal is in working order. A vast quantity of soil will have to be removed, as will also several great blocks of rocks, or dumplings, which have been left near the locks to facilitate the working in connection with the sluices and gates. At the riverside there is also a good deal remaining to be done, but it is not work of a difficult or costly nature. The shore side perhaps is the best for a walk along the canal, but it was upon the opposite bank we strolled, and were much surprised to notice that the sandstone dressing was not to be laid on the face of the bank from the overflow to a point above the top of the locks, the only dressing being a trimming of the surface by taking off all the loose clay and seeing that the rest was firm and solid.

While engaged looking at the many laborers working away at the bottom of the canal, numerous dull reports remind us that further up there is also work going on and we make a move in that direction. Before we are on the hail of the great pump which serves to drain the cutting, the 12 o'clock whistle proclaims that the dinner hour has arrived, and at once the men come hurrying down the lines on the embankment to get their midday meal. Those away down in the cutting make a move for the side, and soon we notice them climbing up the great banks like ants up a brick, a long line of men following each other up rough but serviceable wooden flights of steps. A little further on a group of men gather round one of the portable fires, which glimmers and sends up a feeble smoke heavenwards from the far down level, and there they eat their dinner—the young fellows larking in various ways, while the elder men staidly devote themselves attentively to the important business they have in hand—and mouth. Still further from Eastham some of the men have sat them down on the coupling chains across the truck ends, at rest on the lines, and in that comfortable position they solemnly discuss the half-hour at their disposal. Down in the hollow a steam digger lies idle, the great bucket, with its three staring steel teeth, being supported on a truck, the chain attachments being loosed, and the great artificial navy looking altogether much out of gear. Walking along one of the many truck lines, so observant are we of things going on down below that the simultaneous shout of the laborer and the whistle of a locomotive barely suffice to clear the line of our presence ere the engine rattles noisily past, reminding one very much of Mr. Pancks, the collector. On a level, rather lower than, but ascending to that on which we stand, another engine stands, with a train of laden trucks attached, and after a few preliminary shrieks we are surprised to find the insignificant-looking locomotive haul the heavy trucks up the steep incline at a great speed. Several other engines join in now, and for some minutes the trains are shunted about in every direction, till, all reaching the one level, they are posted off to Ellesmere.

After getting rid of the trains we hear a "tink, tink" of two metal articles in collision, and soon come upon a small boy, who stands near one of the railway points, jerking up and down a wire, to which is attached an iron arm, and this beating on another iron article causes the robust "tink." Upon inquiry the small pointsman is good enough to inform us that he is working the fog signals, just for the fun of the thing, as the air is quite clear. About here a small embankment has been run across the shore, and the outer wall of the canal takes in a portion of the shore, called Pool Bay, which now shows firm and level, contrasting with the cut-up appearance where the rock and clay has been torn out. Across here, too, runs a small aqueduct, carrying out to the river the overflow from a small stream which formerly fell into the river at this point. At present the stream is dammed and the water is diverted into several ponds which serve as reservoirs from where water is pumped to the stationary engines along the line. The overflow is taken off by means of the little wooden aqueduct, which forms quite a pretty feature in the landscape. A little inland from here is Pool Hall, one of the most interesting houses in Cheshire, and full of value to the antiquarian. The hall, which is not far from Hooton Station, is separated from the canal by one field only, and there is unfortunately a possibility of its fall becoming necessary when the canal is complete. The front part of the hall, which is now occupied by Mr. Pickering, a farmer, is Elizabethan, and early of that period, but the back of the house dates from about the middle of the 13th cen-

tury, and one of the gables is a fine specimen of Norman architecture. Inside the house is a magnificent old oak staircase, and throughout the rooms there are many interesting relics. It will, indeed, be a pity if the old hall has to be pulled down for the modern needs of the district, and its demolition will be much regretted.

Returning to the canal side in continuance of our walk, the first building to catch our attention is a most comical one. At the foot of a signal post rods, sticks, and clay have been built up to the height of little more than a yard, and the sun has caked it all together in the form and firmness of a little Highland bothy. A small drain-pipe is the chimney, and at the cheerful little fire inside a couple of lads are warming themselves, evidently pleased with their small but cosy shelter. The cutting about here is not nearly so deep as it is nearer Eastham, and it is evident that much work will yet have to be expended upon it before anything like completion is approached. A great quantity of solid rock has to be got through, and still near Ellesmere Port the ground changes to clay, so that both materials have yet to be faced; but they will doubtless be overcome in as easy and rapid a manner as they have been conquered at the Eastham end. Near Ellesmere Port a number of sheds have been built, and here the men are working away at the carpentry and other industries, all aiding towards the general scheme. Just above the shore stacks of solid timber are built up, and these, we learn, are for forming the bank which takes in a part of the Mersey for the canal. The pile-driving machine is now at work, and under its steady "dump, dump," the foundations of the bank are being rapidly formed. The piles are in four rows, and the breadth of the bank at the base will be 60 feet, the sides sloping in till at the top—a height of 20 feet—the breadth will be about 20 feet. This is a very substantial wall, and calculated to have a big reserve margin of resistance, much beyond the actual requirements. The bank runs across a considerable embayment, and the furthestmost half belongs to the Ince section, which begins at this point, and with which we at present have nothing to do.

Curiosity prompts an inquiry with reference to the various machines employed on the Eastham section, and we learn that twenty-nine steam cranes and ten steam diggers have been in use on the section, but nearly all the diggers are at present idle. Another useful engine is a digger crane, which when not needed for navy purposes may be brought into valued service as a 10-ton crane. Then come derricks of 10, 5, and 2½ tons, half a score of portable steam-engines, a great Cornish pump to lift about 3,500 gallons a minute; five centrifugal pumps, and other appliances. In addition to all these there is enough turning plant in the engineering shops to stock a small establishment, for every bit of work that can be done on the premises is there carried out, everything, indeed, except casting and forging. But to fully appreciate the amount and variety of these things they should be seen and examined, bare cataloguing being a very bald way of enumerating them.

In spite of the death of the great head of the work, Mr. T. A. Walker, the labor still goes on, testifying to his ability after his death even more than during his life, by showing how complete and reliable were his methods of carrying on one of the greatest contracts of the age.

LONDON.

REPORT OF CONSUL-GENERAL NEW.

I have the honor to acknowledge receipt of canal circular dated 31st July, 1889, and in reply thereto have to state that in the district of this consulate-general I find there are four canal companies, viz: The Regent's Canal Company, The Grand Junction Canal Company, The Surrey Canal Company, and The Lee Conservancy.

REGENT'S CANAL.

By courtesy of Mr. E. Thomas, the engineer and manager of the Regent's Canal, I am informed that under the authority of the British Parliament the canal was commenced in the year 1812 and occupied about 8 years in construction, being opened for traffic in the year 1820. It was constructed in the ordinary manner, but differs from other canals by having two locks at each variation of level, side by side, to economize consumption of water.

The total length is $10\frac{1}{2}$ miles. Barges of 100 tons burden, say 78 feet long by 14 feet wide and 4 feet 6 inches draft of water, can pass through. The traffic consists principally of coal, building material, viz: Brick, cement, and stone, also road material and firewood timber, and a considerable quantity of ice. The average for the past 5 years exceeds 1,000,000 tons annually.

This company is managed by a board of directors and staff of officers, and the canal is not used for irrigating purposes; in fact, in this country irrigation is hardly ever required.

GRAND JUNCTION CANAL.

This canal was constructed under an act of Parliament in the year 1873. The length of the main line and its branches is about 140 miles and the carrying capacity of barges navigating this canal varies from 50 to 76 tons, according to the craft and section of canal navigated. This company has power to charge toll for distances of about 100 miles of 16s. $10\frac{3}{4}$ d. per ton, but in point of fact the traffic will only bear a toll of 2s. 6d. a ton over that section, thus showing a large reduction that has now been effected on the expectant sources of revenue at the time of construction.

This canal, for 30 miles from the River Thames at Brentford, Middlesex, was partly constructed by canalizing the rivers Brent, Colne, Gade, and Bulbourne, and is not much used for irrigating purposes.

THE SURREY CANAL.

The canal belonging to this company was constructed in the year 1807. The canal is a short one of only 4 miles in length, being part of a scheme devised in the early part of this century for communication from Rotherhithe, which is about $1\frac{1}{2}$ miles from London Bridge, to Battersea, which is about 3 miles from London Bridge, but the plan was not carried out in its entirety, and the canal terminates at Camberwell and Peckham, suburbs of London. The canal was constructed for the class of barges ordinarily navigating the river Thames, and is campto-sheeted for nearly its entire length, rendering the full width available.

The traffic consists entirely of barges engaged in supplying the wharves and premises on the banks of the canal with goods which enter the company's docks at Rotherhithe.

The premises on the canal are chiefly occupied as tar distilleries, chemical manufactories, wood yards, and a large part of the revenue from the canal is derived from the dues on coals which are brought up the canal to the South Metropolitan Gas Company, whose works have a water frontage on the canal. The canal is virtually part of this company's dock system.

Length of canal	miles..	4
Width at surface	feet..	58
Width at bottom	do....	52
Number of locks .....	.....	1
Lift of locks	feet..	$3\frac{1}{2}$
Length of locks	do....	120
Average load	tons..	80
Maximum draft of boats	feet..	$4\frac{1}{2}$
Maximum width of boats	do....	$17\frac{1}{2}$

THE LEE CONSERVANCY.

The river Lee is a natural stream and was known as far back as the time of Henry VIII, and does not compete in regard to transportation of goods, nor can it be said to be used for irrigation purposes.

I inclose copy of a report which has been furnished to me by the courtesy of Mr. George Corble, clerk to the Lee Conservancy, and which return was originally prepared for the English Board of Trade. The information therein supplied contains all the detail I am able to obtain.*

CANALS VS. RAILROADS.

Generally canals, prior to the expansion of the railway system, had the effect of cheapening the prices of transportation, etc., by transferring traffic from the road to water, but the present network of railroads in this country, particularly in and around this consular district, has diverted the transportation of goods by canals to a very large extent, and where goods are transported by canals, it has been found necessary by those controlling canals to considerably reduce their charges as originally fixed, the competition being keen.

JNO. C. NEW,
Consul-General.

UNITED STATES CONSULATE-GENERAL,
London, October 25, 1889.

[Inclosure in Consul-General New's report.]

REGENT'S CANAL AND LIMEHOUSE DOCK.

The Limehouse dock has a water area of 10 acres, and extensive quayage, with a ship entrance of 350 feet long, 60 feet wide, and sills laid 28 feet below Trinity high-water mark; also an entrance for barges 79 feet long, 14 feet 6 inches wide, and sills laid 22 feet below Trinity high-water mark.

The wharfs and jetties in the dock are provided with hydraulic and other cranes for transshipping and loading coals and other goods up to 15 tons weight.

The dock, which is within and part of the port of London, is most conveniently situate on the north bank of the river Thames, about a half-mile below the Shadwell entrance to the London docks, $1\frac{1}{2}$ miles below London Bridge, and one-third of a mile above the Limehouse entrance to the West India docks, and is close to the Stepney station of the London and Blackwall Railway, which is reached by trains from Fenchurch street station in 8 minutes; and trains run to and from this station to all stations on the Great Eastern Railway, and the London Tilbury and Southend, Thames Haven and London, Woodford and Ongar branches thereof, and also in communication with the trains of the North London Railway Company passing Bow station.

Screw steam vessels to and from Liverpool, calling at Falmouth, Plymouth, and Southampton, leave and arrive at the dock weekly. London agents, Messrs. J. D. Hewett & Co., 101 Leadenhall street, and Messrs. John Allen & Co., 150 Leadenhall street.

The jetties in the dock are capable of transshipping and weighing with great rapidity and small breakage coal from screw steamers and other vessels into craft for the river Thames and other inland navigations. The Regent's Canal communicates with the dock and river Thames, and is navigable for barges of 100 tons burthen, and passes through Stepney, Mile End, Bethnal Green, Hackney, Shoreditch, St. Luke's, Islington, St. Pancras, Marylebone, and Paddington, in which last-named parish it communicates with the Grand Junction Canal.

Large warehouse accommodation and extensive wharf area for storing timber, stone, and other goods are provided within the dock premises.

The company are permitted under a sufferance license (class B), received from the

* Not considered necessary for publication.

honorab!e board of customs, to receive into the dock, and land upon the quays, or tranship into craft for the river or canal, every description of goods and grain (except to bond articles).

The facilities which are now afforded at this company's dock are strongly recommended to the notice of traders and lightermen on the Thames and the Regent's Canal, Hertford Union Canal, Grand Junction Canal, river Lee, and other inland navigations connected therewith, as considerable inconvenience, detention of vessels, and expense, also risk of damage to valuable cargoes, such as grain, etc., in barges, consequent upon navigating the river Thames, would be avoided by using the dock.

The Great Eastern, Great Northern, Midland, and London and Northwestern Railway Companies have their goods termini on the banks of this canal, and the Great Western Railway upon the Paddington Basin.

SHEFFIELD AND SOUTH YORKSHIRE.

REPORT BY CONSUL FOLSOM, OF SHEFFIELD.

PROMOTION OF CANAL TRAFFIC.

Within the past few months a company has been formed in this consular district known as the Sheffield and South Yorkshire Canal Company, Limited. The objects for which this company was established (as shown by its prospectus issued March 9, 1889) are briefly as follows:

To promote and procure the passage of an act of Parliament for the incorporation of a company for establishing an improved water way connecting Sheffield, Rotherham, Doncaster, the South Yorkshire coal fields, and the Don Valley with the sea, and for establishing, acquiring, undertaking, improving, and working of such canals, docks, harbors, water ways, rights of water, and works as may be expedient, and, in particular, to acquire from the Manchester, Sheffield, and Lincolnshire Railway Company the following existing water-ways, viz: The Sheffield and Tinsley Canal, the Dun Navigation, the Stainforth and Keadby Canal, and the Dearne and Dove Canal.

To straighten, deepen, and otherwise improve so much of those water ways as may be requisite to meet the requirements of the traffic to adapt the same for steam haulage and construct larger locks thereon;

To construct a new canal nearly 2 miles in length and 80 feet wide (with three locks each 220 feet long by 30 feet wide, and with a depth of 10 feet of water over the sills) from the existing navigation at Tinsley to a site near to Saville street east, Sheffield, where a large dock or basin (with wharves, cranes, etc.) is proposed to be constructed;

To build a new dock or basin at Keadby with locks to connect the same with the Stainforth and Keadby Canal and with the river Trent, and so facilitate the passage of traffic between the canal and the Trent and Humber; and

To act as common carriers by water as proposed by the bill for the said act or otherwise as may be sanctioned by Parliament, and by the above means to provide for the cheapest transit of raw materials, coal, coke, minerals, and heavy goods of all kinds between the sea and the towns of Sheffield, Rotherham, Barnsley, and Doncaster, the South Yorkshire coalfield, the Don Valley, and the adjacent industrial districts.

The proposed improvement and enlargement of the existing water ways are shown upon the map which accompanies this report.

TRAFFIC.

The canals above mentioned were constructed about 100 years ago, and there has been but little improvement in them since they became the property of the Manchester, Sheffield and Lincolnshire Railway Company in the year 1849. The size of these canals is such as to limit

boats and barges trading between Sheffield and the river Trent to a carrying capacity of about 80 tons each. The use of steam as a propelling power is prohibited, and the length of time required to pass between Sheffield and tide water averages about a week. The locks are small and numerous, and from the canal into the Trent only one boat can be passed through at a time, giving a total of only about twenty boats at each tide. In spite of this unfavorable condition, however, not less than 500,000 tons of through traffic pass the lock at Keadby in the course of a year.

The canals being in the possession of a railway company which reaches the same points between Sheffield and the coast, there is, consequently, no competition in rates or traffic between the two. Thus the railway company's rate on coal for shipment at Hull from South Yorkshire amounts to 2s. 10d. (69 cents) per ton, or double the rate charged by the Aire and Calder Canal over an equal distance from the West Yorkshire Collieries to Goole. The Aire and Calder Canal is no doubt one of the best illustrations in England of successful inland navigation, and has greatly benefited all that part of Yorkshire which it serves.

CANAL VS. RAILWAY TRAFFIC.

In addressing the select committee of the House of Lords on the Sheffield Canal bill, its advocate (Mr. Pember, Q. C.), after referring to the fact that the extensive steel rail works of Messrs. Cammell & Co., of Sheffield, had been driven from the interior to the coast by the excessive freight charges demanded by the railways, spoke as follows :

Now it is not necessary to blame railway companies for charging these rates. I do not affect to blame them, they know best the conditions of their own business. I think personally it may be well that they can not carry such produce as the staples of the heavy trade of Sheffield at rates which are at once possible to traders and satisfactory to themselves. It is quite possible that that may be so. But the Sheffield manufacturers also know the conditions of their business; and if they are to live they know perfectly well that they must have rates which render their life as traders possible, and to get them they must have water transit, and water transit, if it is to be of any use to them, must be water transit of the best order. Nor are they alone in this resolve. Birmingham is also saying the same thing.

I have already had the honor of being consulted by Birmingham and I hope to be associated with Birmingham with the view of improving the canal service between the Severn and the Thames. Manchester has already said it and said it with some emphasis. The truth is no sane man now thinks of establishing a new manufacture of which the product is anything like a product which demands cheap transit in the center of England. They are all looking for a port which is convenient for the fuel, for the raw material, and for the shipment of the manufactured article.

This necessity, I say, arises from the fatal mistake that we have made in Great Britain for many years past, and indeed for a generation or two generations, of neglecting our water ways. In that respect England stands alone. France, Belgium, Holland, Italy, Germany, and the United States are one and all instances of a contrary and wiser policy; they have all done all they can in the last fifteen or twenty years to improve, develop, and foster their water ways and water carriage, and I venture to say, as I have had the honor to say upon even a more important occasion than this, that it is not a day too soon for us to reverse our policy.

It is right that I should at this moment contrast the condition of independent with what I may call "railway-locked" canals and navigations. Indeed, one way to illustrate the usefulness of navigations, in fact, almost the best way, is to see what they do when they are left alone; that is to say, not associated in their management with a railway company. In this immediate neighborhood is the Aire and Calder navigation, which you see running along the top of the map eastwards, in the direction of Goole. I believe that at this moment the nominal capital of the Aire and Calder Navigation Company is £150,000 (\$729,975). Perhaps, in order to be absolutely certain, I ought to have said "not more than" £150,000 (\$729,975), because I happen to know that there are certain persons who think their nominal capital is still less; but I am content to take it at the comparatively high point of £150,000 (\$729,975).

They have for many years past spent enormous sums out of their profits upon the improvement of the navigation, in fact, I may say openly, to the extent of £2,000,000 (\$9,733,000). Their net income last year was £85,000 (\$413,652.50), and it is intended out of this income to spend £30,000 (\$145,995) upon further improvements still. Their total mileage is some 50 miles. The original depth of the navigation when they began was 3 feet 6 inches; it is now in the center, with shelving sides, 10 feet everywhere (10 feet, if you remember, is the point to which we intend to enlarge ours), so that they have brought up the depth alone from 3 feet 6 inches to 10 feet. Their locks were originally 60 feet in length by 14 feet wide; they are now 215 feet long by 22 feet wide. We propose to make ours a little longer, namely, 220 feet instead of 215 feet.

They have steam tugs throughout the navigation which tow numbers varying from fifteen to twenty-five, and even thirty boats, which go by the name of compartment boats. These compartment boats are so called because they have square compartments inside them which are removable; indeed, the compartments themselves float, I am told; each of those carrying from 35 to 40 tons of coal, and they are made of wrought iron. And just let me throw in this fact, that modern as they seem, as you will see from the use that is made of them, they have been in use for the last fourteen years upon the Aire and Calder navigation.

Seven hundred tons of coal is considered, I am told, a convenient train load for the tugs to draw along the canals. The method of unloading these compartments at Goole, which is their port, is very well set out in a pamphlet which I will read and make my own for the purpose; it is also published in a Blue Book. It was described by Mr. Bartholomew in the Blue Book of 1883, issued by the committee on canals. This system of conveyance, said in effect Mr. Bartholomew, when giving evidence before that committee, has been employed upon the Aire and Calder Canal about fourteen years; and then he says, in answer to question 910, that when those compartments reach Goole, "We have there a large hydraulic hoist for the purpose of transshipment; the boat goes into the hoist, and inside the hoist there is a cage, like a colliery cage for raising coals, and within this cage there is a cradle in which the compartment is secured, and when the compartment has been raised to the required height (that of the shoot) it turns over and discharges the coal into this spout, and by that means into the ship; the boat and cradle are then allowed to resume their original position, after which the cage and boat are lowered back, and in lowering the water in one of the lifting cylinders is forced back into the accumulator. There are two lifting cylinders, and in lowering the weight of the compartment and the carriage forces half the water back again into the store accumulator."

Now, therefore, you see what an elaborate system they have there where they are left alone. Further, they have a long string of conveniences for all kinds of traffic, which, I have no doubt, some of my witnesses will explain, and on which they will probably enlarge. As a specimen of those, I am told (I really could hardly believe it at first) that they have an excellent system of telephones along their navigation. They have a regular service night and day; they do the whole distance from Leeds to Goole, which is 31 miles, in from 7 to 9 hours; in fact, the whole thing is as complete as a highly organized railway itself can be. Now that is the way to do business; that is the way in which every water way ought to be treated, and that is the position to which every water way in a manufacturing district ought to be brought.

Contrast this with the position of a canal locked by railway action. Upon the Sheffield navigation there is no steam haulage at all, it is forbidden, although there was formerly, because I find in an old Blue Book of 1835 a description of how the traffic was brought to a certain point and then taken on by steam; but that has now been put a stop to. There is, I believe, a statutory prohibition against the use of steam upon the canal, in fact, they have not got it. The locks, I believe, are only about 70 feet long and sometimes even smaller. I am told that as compared with taking from 7 to 9 hours to do the 31 miles from Leeds to Goole, it takes 10 hours to go from Sheffield to Mexborough, a distance of 10 miles, as you will see upon the east of that map, Mexborough being to the northeast of Rotherham.

Now, again, I am told—though it is almost incredible—that for a boat to get from Sheffield to the Humber it takes a week or more. The distance from Sheffield to the Humber is, from Sheffield to Keadby, 41 miles, and from Keadby all the way to Hull only 26 miles. I will therefore leave you to guess what the distance is from Keadby to Alkborough, which is the junction of the Trent and Humber. Now there you have the contrast. You have steam haulage, these compartment boats, the magnificent mechanical arrangements for loading the shipping from them, and you have your telephones and all the rest of it, and you have a distance of 31 miles performed in from 7 to 9 hours against a somewhat longer distance, taking a week or more. Moreover, the Sheffield Company, who own these navigations, do not act as carriers at all; and as to the compartment boats in trains, with hydraulic machinery for unloading, which I have mentioned, they are of course unknown, and of course it goes without speaking that the telephone is unknown along the navigation. No; I must not do

them an injustice; they have got a bit of telephone from Sheffield to Tinsley, so that it is not absolutely unknown. Then I was upon the point of saying that there is no night service, whereas the night service upon the Aire and Calder navigation is universal.

Again, what is true of the Aire and Calder as to prosperity and energy is true—I do not know whether it is in every particular, but in the main it is true—of the Bridgewater Canal, and the Leeds and Liverpool Canal, both of which are highly prosperous navigations. The Leeds and Liverpool Canal, I believe, pays a very good dividend, and the Bridgewater Canal navigation paid 8 per cent. at the time they were taken over by the Manchester Ship Canal. They paid 8 per cent. in spite of the competition of no less than five railway companies—the Cheshire Lines Committee, the Lancashire and Yorkshire, the Northwestern, the Midland, and the other two that make up the Cheshire Lines Committee, being the Great Northern and the Manchester, Sheffield, and Lincolnshire Companies themselves, who are all trading between Manchester and Liverpool. All this I simply state as natural. I do not so much blame the railway owners; all I say is, we want to mend the existing state of things which arises out of the stagnation that comes of what I will venture to call the unnatural ownership.

After hearing the representative of the Manchester, Sheffield, and Lincolnshire Railway Company, the owners of the canals, in opposition, and other parties in interest, and after the examination of a large number of witnesses upon the subject, the committee reported in favor of the scheme; and having obtained Parliamentary sanction it now remains to be seen whether the capital which is necessary for the acquirement and improvement of these water ways can be raised. The amount necessary for the successful carrying out of the undertaking is estimated at about \$8,516,375. Whether this sum or any sufficient part thereof can be realized from public subscription now remains to be seen.

CANAL TOLLS.

The following statement, showing some of the principal rates charged for toll on the water ways in question, has been kindly furnished by E. Ross, esq., the secretary of the Manchester, Sheffield, and Lincolnshire Railway Company.

Navigation.	Description of traffic.	Rate per ton.
River Dun, Stainforth and Keadby, Sheffield, and Dearce and Dove, between—		<i>Cents.</i>
Sheffield and Keadby	Iron (class A)	78
Do	Iron (class B)	97
Do	Pig and spigal, foreign imported	67
Do	Timber and deals	85
Do	Grain	86
Do	China clay	91
Do	White sand	42
Do	River sand	30
Do	Manure (stable) and night-soil	24
Keadby and Rotherham	Iron, undamagable	73
Do	Wheels and axles	65
Do	Grain	77
Do	White sand	30
Do	River sand	24
Do	Timber and deals	77
Denaby and Keadby	Coal	34
Kilnhurst and Keadby	do	27
Roundwood and Keadby	do	27
Aldwarke Main, Tinsley, Manvers Main, Elsecar, Worsboro and Barsley, and Keadby.	do	27
Chesterfield, between—		
Stockwith and Worksop	Trent sand	36
Stockwith and Kiveton Park	do	36
Stockwith and Staveley	do	36
Stockwith and Chesterfield	do	26
Stockwith and Staveley, and Chesterfield	Potatoes, carrots, turnips, mangolds	73
Shireoaks and Stockwith	Coal	24

Tonnage conveyed over the River Dun, Stainforth and Keadby, Sheffield, and Dearne and Dove canals during the year 1888.....	927, 254
Tonnage conveyed over the Chesterfield Canal, same period.....	62, 016
Total tonnage.....	989, 270

BENJAMIN FOLSOM,
Consul.

UNITED STATES CONSULATE,
Sheffield, November 6, 1889.

IRELAND.

REPORT BY CONSUL REID, OF DUBLIN.

INLAND NAVIGATION IN IRELAND.

The canals and inland navigation enterprises in Ireland are of three classes, viz:

First. Those owned and operated by private companies or corporations. Under this head are the following: The Grand Canal, with a total length, including branches, of 165 $\frac{3}{4}$ miles; the Barrow Navigation, partly canal and partly river, 42 miles; the Upper Boyne, all river, 6 miles, completed in 1800; the Lagan, mostly river, 26 miles; the Newry, canal and river, 35 miles; the Suir, all river, 16 miles; the Royal Canal, 96 miles. These of course are maintained out of funds belonging to their respective companies. From their importance, the Grand Canal, the Royal Canal, the Barrow Navigation, and Lagan Navigation will be considered separately and in greater detail further on. The improvements upon the routes described by the Upper Boyne, the Newry, and the Suir were largely accomplished by means of assistance in the forms of loans of public money, or by grants from general or special taxes. Some of these loans have been paid and some remitted. There is no considerable traffic upon these canals now, and the profits derived therefrom are small.

Second. Those owned and operated by the Government and maintained out of imperial funds. This class is composed of the following lines: The Lower Boyne, canal and river, 19 miles; the Maigue, all river, 8 miles, improved in 1751; the Shannon, chiefly river, 158 miles; the Tyrone, all river, 4 miles; the Ulster Canal, 44 miles. The improvement or construction of these channels, as the case may be, was accomplished by direct grants of the public funds and advances realized from local assessment. The latest reports rendered by the commissioners, under whose management are these several lines of navigation, show that the total annual receipts amount to £6,584, and the annual disbursement for expenses for all purposes to £6,192. Thus it will be seen that the receipts derived from rents, tolls, etc., make them a trifle more than self-sustaining. Of the lines mentioned, the Shannon Navigation and the Ulster Canal are the most important. The improvement of the former involved an outlay of £683,312, and the construction of the latter about £170,000.

Third. Those under the direction of local trustees. This class includes the Ballymore and Ballyconnell, mostly canal, 37 miles; the Lower Bann, mostly river, 50 miles; the Upper Bann, all river, 21 miles, and Lough Corrib, mostly river, 23 miles. The improvement or construction of these lines, as described, was also accomplished by grants of public

money and advances secured in local taxation, amounting in the aggregate to about £600,000. These public works covered a period from 1845 to 1859. The group, as given above, is also a little more than self-sustaining. With the exception of the first-mentioned, the latest figures show that the total annual receipts are £3,261, and the total disbursements are £2,553. As stated, these works are managed by local trustees, representing the property interests which are contiguous to the several lines. In case of a deficiency, the difference is made up by means of local taxation. In case of a surplus, the local taxation is less by that amount. The system of management is the same as that which applies to public highways.

THE GRAND CANAL.

This is the most important artificial water way in Ireland. Its main line extends from Dublin westward to the Shannon River, and from thence westward to Ballinasloe with branches to the Liffey, Robertstown, Blackwood reservoir, Monastereven, St. James' Well, Athy, Mountmellick, Edenderry, and Kilbeggan. Its summit level is 279 feet above sea level, which point is 26 miles west of Dublin. The locks upon this canal are 60 feet in length, 13 feet in width, and have 5 feet lift. Although steam is used somewhat horses are used principally as the power for moving the boats. The traffic upon this canal amounts to 600,000 tons annually. The Grand Canal now earns for the shareholders £1 15s. on each £100 of the capital stock. The construction of the Grand Canal was commenced in 1753, and the main line was completed in about 1800. The line west of the Shannon River and the branches were opened in 1830. The entire work involved an outlay of £2,000,000. A considerable portion of this amount was made up by grants from special or general taxes and also by loans, a part of which has been paid to the Government, and a part of which has been remitted. The present capitalization of the company is £165,000.

THE ROYAL CANAL.

The Royal Canal proceeds northwesterly from Dublin to Cloondara, on the Shannon, with a branch to Longford; the total length of channel being 96 miles. Its summit level is 324 feet above sea level. It is fed from Lough Owel, near Mullingar. The dimensions of the locks are 70 feet in length, 13 feet in width, with 5 feet lift. The Royal Canal Company was organized in 1784. The first 46 miles of the channel was completed in 1813. The remainder of the work was completed in 1822. It received large assistance from the Irish Parliament, and from the Union after that was established. The total cost of the work was something over £1,900,000. In 1813 the original company became insolvent, the charter was forfeited, and the property transferred to the directors-general of inland navigation. Again, in 1845 the Royal Canal was transferred to the Midland Great Western Railway Company, the consideration being £298,050. An essential condition of the transfer was that the purchaser should maintain the navigation and not vary the tolls except with the assent of the lord lieutenant of Ireland. Being its own competitor, however, the company does not utilize the facilities of the canal to any considerable extent. The annual tonnage amounts to only 86,500, on an average.

THE BARROW NAVIGATION.

This route connects the Athy branch of the Grand Canal with the tidal part of the river Barrow, below St. Mullins, and affords water communication to Carlow, Leighlin Bridge, Bagnalstown, Goresbridge, and Graignamanna and thence by tidal part of Barrow to New Ross and Waterford. The work was commenced in 1759 and up to 1790 cost £80,769, about one-half of which was derived from public sources. It also received other grants after the Union, but the exact amount is not available. There is considerable traffic upon this route, but I have been unable to get figures showing annual tonnage; the profits to the shareholders are moderate.

THE LAGAN.

This route extends from Belfast, partly in the river and partly by canal, via Lisburn and Moira, to Lough Neagh. I have been unable to procure statistics relative to the traffic upon this canal, but I have learned from authoritative sources that it is considerable and that the earnings to the shareholders are reasonably liberal.

TOLLS.

Tolls are exacted upon all channels as above described, and are quite uniform as regards the three classes, viz, those owned by private companies, those operated and maintained by the Government, and those under the direction of local trustees. The rate on the Grand Canal varies from 7 shillings to 12 shillings per ton for 160 miles, the respective equivalents of which in American money would be 84 cents and \$1.44. Between these limits the particular rate is determined by the class of freight.

CANAL VS. RAILWAY CHARGES.

The effect of inland navigation in Ireland has been and is to keep the rates of transportation at a minimum figure at all points tributary to these lines. As an illustration of this point I have only to say, upon good authority and as the result of personal investigation, that the rates exacted by railroads at points upon their lines where there is no competition are nearly twice as great as at other points where competition is offered by canals and other navigable water ways. Hence their usefulness in Ireland has outlived the introduction of railways. In the matter of rates they serve as a potential and permanent regulating force. The prevailing rates for carrying freights upon canals and other inland water ways in Ireland are on an average from 10 to 20 per cent. less than are required by the railways for similar services. Of course, the carriage of passengers upon the canals and improved streams has entirely ceased since the introduction of railroads, which began about 1841.

TRAFFIC.

The shipments upon the inland lines of navigation in Ireland consist mostly of grain, porter, malt, agricultural products, coal from seaports, turf or peat, brick, sand, etc.

Considering the extent of inland navigation facilities, there is, of course, a limited traffic carried on by these methods. The cause, however, is easily understood. It is to be found in the depressed condition of the country agriculturally, there being but little surplus to ship to

the seaports. A further reason is that there is a very limited amount of manufacturing being done in the interior of the country, a fruitful source of shipments being thus wanting. I am informed that in England the annual tonnage upon canals of similar capacity is two or three times as great as in Ireland, the difference being justly ascribed to the operation of great industries that are wanting in Ireland.

IRRIGATION CANALS.

There have been no canals built, nor are there any being used for irrigating purposes in Ireland. Owing to the great rainfalls here no service of this kind is required. On the contrary, some of the canals were built, partially for drainage purposes, and are maintained largely because of the benefits resulting from this service. In some sections the low lands have settled 20 feet in consequence of being drained by the canals. The arable territory has thus been considerably increased.

COST AND EXTENT.

The extent of the canals in Ireland and of rivers which have been rendered navigable by improvement is 708 miles. The total cost of the construction and improvement of these channels is given by good authority at £4,722,211. This amount has been made up as follows: £385,364 from counties; £2,296,349 from private sources; and £2,040,098 from grants of public money. This sum in United States money would be about \$23,000,000. Concerning the limited size of the country the amount is large, but from the highest consideration of public policy the large expenditure was justified.

As I have shown, in no case do these improvements fall below the self-sustaining point, while in several instances, especially including the more important lines, the net earnings amount to a fair profit for the shareholders.

Of course the traffic upon these channels would be largely increased if a system of free tolls obtained as is the case in many similar improvements in the United States.

ALEX. J. REID,
Consul.

UNITED STATES CONSULATE,
Dublin, September 20, 1889.

BELFAST.

REPORT BY CONSUL RUBY.

There are three canals in this district, all connected, however, by "Lough Neagh and Lough Erne," making a continuous line from this port to the west coast of Ireland.

THE LAGAN CANAL.

This is owned by the Lagan Navigation Company. The works were commenced by the commissioners of Ireland navigation in Ireland, the expense being defrayed by a local toll on beer, ale, and spirits imposed by an act of 1753.

In 1771 prosecution of works was handed to local commissioners, who raised money on the securities of the tolls. Afterwards these creditors were constituted a company by act of Parliament. The canal extends from Belfast to "Lough Neagh," length 26 miles, with 26 locks capable of passing lighters 62 feet by 14 feet 6 inches with a maximum draft of 5 feet 6 inches.

The traffic is about 156,000 tons per annum, consisting of coal, Indian corn, timber, slates, bricks, etc., and return cargoes from Lough Neagh of sand for building purposes.

The company is managed by a Belfast board of directors, with secretary and manager of works.

The company are not carriers. The lighters trading are owned by different individuals. Wherever the canal touches railway rates are brought down to canal rates. Roughly, the effect in cheapening transportation would probably be about from 15 to 25 per cent., or perhaps even more.

THE ULSTER CANAL.

The works on this canal were commenced by the Ulster Canal Company under an act of 1826. Loans to the extent of £130,000 were made by the commissioners of public works in Ireland. In 1865 the canal was transferred to the commissioners in discharge of the debt. More money was expended on the canal, but under the commissioners it has been kept in such want of repair and want of water that there could be no traffic. By an act of Parliament, passed in 1888, it was transferred to the Lagan Navigation Company as a gift, with £3,500 towards cost of repairs, the company being obliged to keep it in order for the public, charging fees regulated by act of Parliament.

It is now being put in order. The canal extends from "Lough Neagh" to "Lough Erne." Length, 44 miles, with twenty-six locks capable of passing lighters 65 feet by 11 feet, and with a maximum draft of 5 feet when repaired.

THE COAL ISLAND CANAL WORKS

Commenced in 1732 by the Commissioners of Ireland, and navigation in Ireland continued in their charge until 1787, when the works were transferred to parties undertaking to complete and extend the canal. In 1800 the navigation came into the hands of the directors general of Ireland, and between 1800 and 1831 a sum of £25,240 was expended upon the works. In 1831, on the absolution of the directors general of Ireland navigation, the management was transferred to the commissioners of public works, in whose charge it has since continued, and a sum of £5,177 has been expended by them.

Under an act of 1888 it has been transferred as a gift to the Lagan Navigation Company, with obligation to keep it in order for the public, charging tolls regulated by act of Parliament. The canal extends from the Blackwater River, which runs into Lough Neagh, to the town of Coal Island. Length, 4½ miles, width 7 locks capable of passing lighters 62 feet by 14 feet 6 inches, with a maximum draft of 4 feet 9 inches. Traffic, about 15,000 tons per annum.

CANAL VS. RAILWAY RATES.

Railroad freight and passenger rates are higher here than in the United States. Canal competition is more effectual in reducing rates

here for the reason that navigation does not close during the winter months.

SAMUEL G. RUBY,
Consul.

UNITED STATES CONSULATE,
Belfast, August 19, 1889.

SCOTLAND.

REPORT BY CONSUL BRUCE, OF LEITH.

THE UNION CANAL.

The only system of inland navigation within the limits of this consular district is the Union Canal, an artificial water way, extending from Port Hopetown, in the western suburbs of the city of Edinburgh to a junction with the Forth and Clyde Canal, at Port Downie (a large basin at Lock 16), adjoining the town of Falkirk, in the county of Stirling.

The construction of the Union Canal was undertaken in the year 1817. It was opened for 1822, but as a property it proved a great failure. The returns from all departments—passengers, parcels, and miscellaneous goods, coals, stone, and other minerals, manure, etc.—proved much less than had been anticipated. The real returns during the 7 years after opening did not amount to \$85,000 a year, while the estimated returns had been set down at \$275,000 a year. The canal was not intended for ship transit, but solely as a water way of inland navigation for passenger traffic and merchandise between places on its own banks, and chiefly between Edinburgh and Glasgow, and, therefore, it was for a long period generally called the Edinburgh and Glasgow Canal.

The company owning it worked their business with great spirit, and adopted every available means in the endeavor to make their enterprise a paying one, or even to raise it to a fairly hopeful condition; but when the Edinburgh and Glasgow Railway was opened, February 18, 1842, it was seen that the canal could not long survive as an independent system of passenger and goods traffic between the two cities. A brisk competition was maintained for sometime with little success, and ultimately, in 1849, the Union Canal was amalgamated with the Edinburgh and Glasgow Railway, both of which undertakings in 1865 passed into the hands of the North British Railway Company. The Union Canal therefore, although still remaining as a work, is quite absorbed as a business in the interests of the railway.

The organized capital stock of the Union Canal was originally \$1,202,500, of which \$1,200,000 was paid up. The cost of making and completing exceeded that amount by \$1,100,000.

The present capital stock is \$1,045,000. Of this, the amount in stocks and shares is \$570,000, and loan capital \$475,000.

The rate of dividend paid as per terms of purchase is about 6 per cent., which, however, has not been earned by business.

The total length of the Union Canal, from Port Hopetown at Edinburgh to the junction with the Forth and Clyde Canal at Lock 16, is 31½ miles.

The medium width at top of bank is 40 feet, at surface of water 37 feet, and width of water at bottom of canal 20 feet. The depth of water is 5 feet.

There are eleven locks $12\frac{1}{2}$ feet wide. Depth of water on sill of locks 5 feet 9 inches. Total rise or fall of locks 10 feet 3 inches.

Three aqueducts, respectively, 810 feet, 600 feet, 400 feet. Width of aqueducts 12 feet 6 inches. Height of these, respectively, 65 feet, 76 feet, and 85 feet.

One tunnel in the neighborhood of Falkirk within a short distance of the western terminus at lock 16 is 696 yards in length, 15 feet high above water level. Width of water line 13 feet in tunnel.

The reservoir which supplies the canal with water has a capacity of about 196,000,000 cubic feet.

The boats in use are 66 feet from stem to stern, their width 11 feet 3 inches, all drawn by horses.

The total tonnage in the year 1888 was 129,411 tons. During same year the total revenue was \$36,300 and total expenditure \$11,810.

The traffic consists entirely in conveyance of coals, stone, bricks, and other minerals, and manure.

The present owners are merely toll-takers, not carriers. Other people put on the barges or boats.

The management of this canal is entirely in the hands of the North British Railroad Company.

THE FORTH AND CLYDE CANAL.

The Union Canal at its western extremity terminates in the Forth and Clyde Canal, an artificial navigable line of communication between the Firth-of-Forth and the Firth-of-Clyde.

From the Forth at the port of Grangemouth the navigation into the canal runs about a mile up the river Carron from low-water mark in the Firth to the first lock, where there are extensive harbor accommodations. Passing southwesterly through Grahamstown and the Carron Iron Works the canal proceeds to Camelon and reaches Lock 16, where it attains an elevation of 128 feet above the level of tide mark at Grangemouth. At Lock 16 is the large basin called Port Downie, from which the canal sends off on its east side the Union Canal navigation to Edinburgh, above mentioned. At Windford Lock, near Castlecary, it attains its highest elevation, and continues to preserve the same onwards past Port Dundas at Glasgow, on the one hand, to the junction of the Monkland Canal and onward on the other till near the aqueduct across Kelvin water. Thence it continues to the western terminus in the river Clyde at Bowling Bay, near the village of Bowling in Dumbartonshire on the road from Dumbarton to Glasgow.

The work of excavation was begun in the year 1768, but, on account of unforeseen difficulties, by reason of inexperience of its projectors in such schemes, the canal was not completed till 1790.

Up to the month of January succeeding the date of its completion the total cost of the canal was \$1,650,000.

The Forth and Clyde Canal was incorporated with the Monkland Canal in the year 1846. The total cost of the two canals was \$5,451,900.

The extent of the Forth and Clyde Canal in all its parts is $38\frac{3}{4}$ miles. The navigation direct from the Forth to the Clyde is 35 miles; the side branch to Port Dundas $2\frac{3}{4}$ miles; the continuation to Monkland Canal 1 mile.

The number of locks on the eastern part of the canal is 20 and on the western 19, the difference being occasioned by the higher level of water in the Clyde at Bowling Bay than in Grangeburn or the Carron at

Grangemouth. Each lock is 74 feet long and 20 feet broad, and procures a rise of 8 feet.

The locks admit vessels of 68 feet keel, 19 feet beam, and 8½ feet draft of water.

The greatest altitude of the canal is 156 feet; its medium breadth at the surface 56 feet, and its medium breadth at bottom 27 feet.

The canal is crossed by 33 drawbridges, and passes over 10 large aqueducts, as also 30 smaller ones or tunnels. The aqueduct of greatest dimensions is one across the River Kelvin at Maryhill, begun in June, 1787, and finished in April, 1791. This structure consists of 4 arches, is 83 feet high, spans a valley 400 feet wide, and was completed at an outlay of \$42,500.

Water is stored and supplied by 6 reservoirs, covering about 700 acres, and containing upwards of 12,000 lockfuls of water.

The cost of the canal originally, including all outlay up to the month of January succeeding its completion, was \$1,650,000. The tonnage dues imposed were, from sea to sea, 5s. 10d. (\$1.41); from Grangemouth to Port Dundas, 3s. 10d. (93 cents); from Bowling Bay to Port Dundas, 2s. (48 cents). Subsequently tonnage dues were greatly reduced, making the rate not more than 1½d. (or 3 cents) per mile, but they continued to be remunerative.

Prior to 1846, when the Forth and Clyde Canal was incorporated with the Monkland Canal, the revenue of the former rose to the comparatively great height of £95,475 (\$464,629.08) and four years later the revenue of the 2 canals was £115,621 (\$462,669.60).

In the year 1867 the two canals passed into the possession of the Caledonian Railway Company, and that company has ever since had the entire management of both of those systems of navigation.

THE MONKLAND CANAL.

This is an artificial navigable communication between the city of Glasgow and the district of Monkland, in the county of Lanark. Commencing in the northern suburbs of Glasgow at Port Dundas, where it was brought into junction with the Glasgow branch of the Forth and Clyde Canal, it proceeds east-southeastward through the parish of Old Monkland to the river North Calder. The canal sends off four branches, one about a mile in length to Calder Iron Works, near Airdrie, in the parish of New Monkland, one about a mile in length to Gartsherrie Iron Works, one about a quarter of a mile in length to Dundyvan Iron Works, and one also about a quarter of a mile in length to Langloan Iron Works, all in the parish of Old Monkland.

The canal originally was projected as a measure for securing to the inhabitants of Glasgow a constant and plentiful supply of coal. The corporation of the city adopted the project, and, having employed the celebrated James Watt to make surveys of the ground, obtained an act of Parliament for carrying out the design, and subscribed a number of shares to the stock.

The undertaking was begun in the year 1761, and the operations were continued until about 10 miles of the canal were formed. The first two of those miles, extending from the basin to the bottom of Blackhill, are upon the level of the upper reach of the Forth and Clyde Canal; the other 8 miles, commencing at the top of the Blackhill, are upon a level of 96 feet higher. Between those levels the communication was at that primitive period carried on by means of an inclined plane, upon

which the coals were lowered down in boxes and restarted on the lower level.

The capital declared necessary in order to complete the work was £10,000 (\$48,665), divided into 100 shares, but this was found to be quite insufficient, as, besides expending it, debt had been incurred, and the undertaking, in this unfinished condition, produced no revenue. Ultimately the whole stock of the company was brought to sale, and was purchased by Messrs. William Stirling & Sons of Glasgow. On acquiring the property these gentlemen proceeded to complete it, and in conjunction with the proprietors of the Forth and Clyde Canal, procured an act of Parliament empowering the latter to unite the two water ways by forming a cut from their basin at Port Dundas to the Monkland Canal basin, and executing other works connected with and needful for the navigation. As much as £100,000 (\$486,650) was understood to have been expended upon these works.

The width of the Monkland Canal at top is 35 feet and at bottom 24 feet. Upon the lock sills the depth of water is $5\frac{1}{2}$ feet.

From the river Calder and neighboring streams and from the reservoir near Airdrie, having an area of 300 acres, water is supplied to the canal.

By reason of the advantage possessed of easy communication with both the Eastern and Western Seas, and because of its unlimited command of coal, the vicinity of the Monkland Canal has always been reckoned favorable for the establishment of manufactures, such as iron works and others of a like nature.

The revenue of this canal was for a long time entirely absorbed by the outlay required for its extension and improvement. A dividend first began to be made in the year 1807, when the gross revenue amounted to £4,725 (\$22,994.21). In 1814 it was £5,087 (\$24,755.88). From then to 1825 there was little amendment in it, but in the latter year a great impetus was given to the traffic by the establishment of iron works in the neighborhood of Monkland.

When railways were first started in that part of Scotland the Monkland Canal Company reduced their dues to about one-third of the rate which had been charged till that period. Many improvements followed, such as the formation of extensive loading basins and wharves for the reception of traffic from the mineral railways, also the making of new locks, including two entire sets of four double locks each, and these were constructed at an outlay of £30,000 (\$145,995).

The Monkland Canal and the Forth and Clyde Canal became one concern in the year 1846.

The purchase price of the Monkland Canal to Messrs. Stirling & Sons in the year 1789 is said to have been only £5 (\$24.33) per share, but the purchase price in 1846 was £3,400 (\$16,546.16) per share to the Forth and Clyde Company.

The two canals are now entirely controlled by the Caledonian Railway Company, both lines of navigation having come into possession of that company in the year 1867.

THE CALEDONIAN CANAL.

This is a navigable line of communication through the Great Glen of Scotland, which extends across the country directly southwest from the Moray Frith, between the mouth of the River Findhorn and two bold promontories called the Sutors of Cromarty, onward to the Island of Lismore, dividing the county of Inverness and the Highlands generally

into two nearly equal parts, while it connects the German Ocean and the Atlantic at those points.

The northeast end of the canal is occupied by about 23 miles of the narrow or upper portion of the Moray Frith; the southeast end is occupied to the extent of 32 miles by the sea-lochs Loch Eil and Loch Linnhe, and the intermediate portion has a total length of 60½ miles, of which 37½ consist of the four natural sheets of water named Loch Dochfour, Loch Ness, Loch Oich, and Loch Lochy. This intermediate portion is the region of the Caledonian Canal, which comprises works at its extremities and 23 miles of dry cutting.

One of the principal objects in constructing this canal was to prevent the delay of vessels going through the Pentland Firth and around Cape Wrath during westerly winds.

The necessity for constructing the Caledonian Canal was brought under notice of the British Government during the latter part of last century, and a survey of the line was made by the celebrated James Watt about the year 1773, but from many causes the work was delayed, and Mr. Watt's report was not acted on. Subsequently, however, the project of forming the canal was again pressed on the attention of the government, and in the years 1803 and 1804 a body of parliamentary commissioners caused a resurvey of the line to be made. The surveyor in his report calculated that a uniform depth of 20 feet of water would be required, and locks measuring 170 feet in length by 40 feet wide, and his original estimate of the outlay necessary for such an undertaking was £350,000 (\$1,703,275).

The work of excavation was not begun till the year 1805. Many causes operated in delaying the work thereafter, among which may be mentioned the rapid rise in wages and in the prices of many articles during the period onwards to the years 1812 and 1813, the advance in many cases being as much as 50, 70, and even 100 per cent., other unforeseen difficulties in the conveyance of materials required in dredging operations, etc.

Ultimately the commissioners were led to open the canal in the year 1822, when it was only partially finished. Numerous accidents resulted from this premature opening, certain portions of the undertaking being failures, the repairing of which was a source of continual expense and frequently caused the navigation to be interrupted.

Up to the time of the canal being opened its total cost was £905,258 (\$4,525,438.05); to the 1st of May, 1827 £973,271 (\$4,736,423.31), and to the 1st of May, 1844, £1,070,173 (\$5,207,996.90).

Notwithstanding the outlay, it was found necessary to supplement the work already done by making extensive additions and repairs, and, after being closed for a time the canal was reopened in April, 1847.

From time of commencement till the 5th of May, 1849, the total expenditure on account of the canal was £1,311,270 3s. 2d. (\$6,381,296.22).

From the published reports it appears that there are very great difficulties and that there has been much expense incurred in maintaining the up-keep and effective working of the navigation through the Great Glen, while the receipts have not been increasing in same ratio.

The reports show that the receipts have been of late as follows :

For year ending April 30—	£	s	d	
1857	7,229	13	5	= \$35,183.19
1888	6,748	0	4	= 32,839.22
1889	7,236	6	3	= 35,215.51

They show the expenditure in same years, thus:

For year ending April 30—	£	s	d	
1887	7,602	14	5	= \$36,998.63
1888	10,507	9	8	= 51,134.86
1889	10,407	4	7	= 50,646.77

It appears that, by reason of the decay which has been rapidly going on in many parts of the original structure, much of it has to be renewed and otherwise improved; that in response to an application for assistance the Government of Great Britain has sanctioned the sum of £5,000 (\$24,332.50) as a contribution towards liquidating debt already incurred by the commissioners of the Caledonian Canal, and that it is hoped that Parliament will approve of further annual sums being devoted towards the renewal of the original structure, as suggested by the report made by the superintendent.

The following table exhibits the amount of traffic on the Caledonian Canal during the past 2 years, with increase and decrease thereon:

Account of vessels navigating the Caledonian Canal during the two years 1887-'88 and 1888-'89.

	Sailing vessels.		Number of passages by steamers.	Total number of passages.	Amount of tonnage dues.
	Number of passages through canal.				
	East to West Sea.	West to East Sea.			
Total for year ending April 30—					
1889	424	345	218	1,104	2,091
1888	381	218	157	1,140	1,896
					\$23,860.80
					23,824.80
Increase	43	127	61		195
Decrease				36	
					36.00

THE CRINAN CANAL.

This is a work at the north end of the peninsula of Cantire (otherwise Kintyre) in the County of Argyle, intended to afford a water way between Loch Gilp and the Atlantic Ocean in order to avoid the difficult and circuitous passage of 70 miles around the Mull of Cantire.

Under an act of Parliament the formation of this canal was commenced in the year 1793 by subscription of shareholders, and was opened on July 18, 1801.

The sum subscribed by proprietors and first expended upon the work was upwards of £108,000 (\$525,582). This amount proved to be quite insufficient for carrying out the work to completion, mainly by reason of the intersection of the line by whinstone rock and peat moss, and, this canal being deemed of national importance, advances were made subsequently by the British Government under authority of Parliament to the extent of about £75,000 (\$364,987.50). In order to secure this sum the canal was transferred on mortgage to the barons of exchequer in Scotland, whose functions subsequently devolved on the lords of the treasury.

A further advance was made in the year 1817 and the act of Parliament which authorized it contained a provision that it should be expended under the control and superintendence of the commissioners of the Caledonian Canal, who undertook to continue the management of the Crinan Canal after expenditure of said advance, and it has therefore remained ever since under their management.

The Crinan Canal is about 9 miles long and contains 15 locks, 13 of which are 96 feet long, 24 feet wide, and 12 feet deep, and 2 locks are 108 feet long and 27 feet wide.

Eight of the locks occur in the extent from Lock Gilp or Ardrishaig at the east end, and 7 in descending to Crinan at the west end.

The canal is chiefly used by small coasting and fishing vessels, and by the steamboats which ply between Inverness and the Clyde.

It is navigable by vessels of 200 tons burden. The small passage steamers do the distance from one terminus to the other, including the locks, in about 2 hours.

It is expected that the Isthmus of Cantire at no distant date will be cut off from the mainland by the formation of a ship canal connecting East and West Locks Tarbert. The cost of such an undertaking has been estimated at £140,000 (\$681,310).

The eighty-third and eighty-fourth reports of the commissioners of the Caledonian Canal controlling and managing the Crinan Canal show the business of the latter done during past 3 years to be as follows:

Receipts during year ended April 30—

	£	s.	d.
1887.....	4,854	9	0 = \$23,642.18
1888.....	4,814	10	5 = 23,429.80
1889.....	5,129	7	5 = 24,962.08

Expenditures during year ending April 30—

	£	s.	d.
1887.....	7,343	16	5 = 35,738.78
1888.....	4,610	8	4 = 22,436.72
1889.....	4,954	17	8 = 24,112.93

Although the Crinan Canal appears to be in a better condition financially than the Caledonian, some renewals and repairs have to be made which must involve considerable outlay, and it seems that sometime in the future the commissioners will have to provide for the expense of lowering the summit level of the Crinan Canal, which is much desired for several important reasons.

The following statement sets forth the amount of traffic on the Crinan Canal during the past 2 years, and the increase thereon:

Comparative statement of the number of boats and amount of canal dues of Crinan Canal for years 1887-88, and 1888-89.

	Number of steamers.	Number of vessels.	Number of boats.	Number of passages.	Dues on steamers.	Dues on vessels and boats.	Transit duty.	Total.
Year ending April 30—								
1889.....	262	1,335	350	1,947	\$1,281.37	\$12,822.51	\$3,383.60	\$17,487.48
1888.....	258	1,288	254	1,800	1,275.48	12,175.73	2,638.73	16,089.94
Increase.....	4	47	96	147	5.89	646.78	744.87	1,397.54

From the foregoing description of the various lines of inland navigation at present in use in Scotland it will be noted that the three first mentioned, namely, the Union, the Forth and Clyde, and the Monkland, are all connected and worked as one system of water carriage managed and controlled entirely by railway companies.

The Caledonian Canal and the Crinan are each quite independent of railways, but both are controlled and subsidized by the Government of Great Britain.

Therefore, in the first instance there is no competition as to rate of cargo and the latter independent systems have no competing lines of transit.

I will further add that there are no irrigating canals in Scotland.

PROPOSED SHIP CANAL.

There is a large ship canal now under consideration, a matter probably not of the near future but likely to be ultimately accomplished, which points to a water way for large ships and steamers from the Firth of Forth to the Clyde. There are two routes recommended: One involving deep cutting, joining the Forth and Clyde with tide water, estimated to cost \$60,000,000; the other by locks joining the Forth with Loch Lomond and Loch Long, thus making an outlet to the Atlantic a few miles west of Glasgow. The estimated cost of this route is about \$38,000,000. At a recent meeting of the promoters of this proposed canal from the North Sea to the Atlantic, which I had the good fortune to attend, the latter route seemed the most feasible and received the weight of commendation.

One object to be attained by this canal is the quick and easy transportation of warships from one side of Scotland to the other, and is therefore related to the subject of coast defense. It is also claimed that much of the shipping from northern Europe, notably Hamburg, Antwerp, etc., would choose this route to the west, thus avoiding the boisterous English Channel and the still stormier route in certain seasons via the north of Scotland. It would also furnish Edinburgh, at the port of Leith, a direct shipping communication to the United States without reshipment at Glasgow.

It is sufficient, however, at present to say that the matter is still a project, and has not yet obtained even the uncertain recognition of probability.

WALLACE BRUCE,
Consul.

UNITED STATES CONSULATE,
Leith, February 27, 1890.

GLASGOW.

REPORT BY CONSUL BROWN.

There are but two or three canals of any considerable importance within the district, or Scotland for that matter.

I quote from Annandale's Encyclopedia as follows: "In Scotland there are the Forth and Clyde Canal, 35 miles, the Caledonian (including lakes), 60½ miles, and several others of no great extent."

THE CRINAN CANAL.

I note one omission, of some importance, perhaps, in view of the use now being made of it, viz: The Crinan Canal between Crinan and Ardrishag, and now used as a sort of connecting link between pleasure resorts and quite extensively used by passenger boats and also for some freighting.

THE CALEDONIAN CANAL.

The Caledonian, which is by far the most important canal in Scotland, connects Oban on the west with Inverness on the east coast. We give a condensed description from the authority quoted above.

The Caledonian Canal was constructed in order to shorten the passage from the east coast of Scotland to the west coast and to the north of Ireland, and also to enable vessels to avoid the dangerous navigation round the north coast of Scotland. It runs from the Moray Firth, east coast, to Loch Eil, an arm of the sea on the west, passing through Loch Ness, Loch Oich, and Loch Lochy. The canal proper therefore only occupies about 22 miles, but to this may be added over 4 miles of Loch Ness, which had to be deepened by dredging. It has 27 locks including the tide locks, one of them 170 but most if not all the others 180 feet long, and all 40 feet wide, thus opening a ship navigation through the country, rising at the summit level 94 feet above the tidewater of the eastern coast and 96½ feet above that of the western.

At Fort Augustus, where it leaves Lock Ness, the canal is cut through the glaces of the fortification. From Lock Ness, passing in a westwardly direction of the canal to Loch Oich, 1½ miles, the land is 20 feet above the water line, which, with the depth of water in the canal, makes an excavation the distance of 40 feet in depth, with a bottom of 40 feet in breadth. To save rock-cutting in descending in the westwardly direction, as before, from Loch Oich to Loch Lochy, the natural difference of the surfaces of the two lakes being 22 feet, the whole area of Loch Lochy, which is 10 miles in length and one in breadth, is raised 12 feet. In the last 2 miles, before the canal in its westerly direction enters Loch Eil, there is a descent of 64 feet, which is passed by eight connected locks, each 180 feet long by 40 in breadth. These locks are founded on inverted arches, exhibiting a solid and continuous mass of masonry 500 yards in length and 20 yards wide. The gates are of cast-iron. In the distance of 8 miles from Loch Lochy to tide water in Loch Eil, the canal in passing along the northwesterly bank of the river Lochy crosses, by aqueduct bridges, three large streams and twenty-three smaller ones. The canal was constructed under the direction of Thomas Telford, and cost about \$6,500,000. It has not been a profitable speculation at any period of its use.

Vessels of 500 to 600 tons can pass through it with a full load. The act for its construction received the royal assent July 27, 1803, and work commenced the same year, but not completed till October 30, 1822. The distance between western ports of Great Britain and also of inland to the North and Baltic Seas is shortened several hundred miles. Notwithstanding these facts, the canal is said to be used but little for the transit of merchandise and has no perceptible effect as to rates upon the railways.

The canal from Forth to Clyde is much older, having been commenced in 1768 and completed in 1790. It, too, has largely gone into disuse to a very great extent, except for pleasure boats loaded with tourists. At the early period of its use large traffic is said to have been carried upon it.

The Crinan having been referred to as omitted by Annandale from the list of important canals, was commenced in 1793 and completed in 1801. The traffic upon this canal is said to be, comparatively speaking, quite extensive.

MISCELLANEOUS.

The canals of Scotland do not now and perhaps never did pay except in convenience to the people before railways were as numerous as now. The canals are owned by the government, tolls upon the vessels according to tonnage, freight carried and passengers, being collected for their use.

Possibly at first the canals may have had, but do not now, it is believed, have any effect in cheapening the prices of transportation, etc. There are no irrigating canals in Scotland.

LEVI W. BROWN,
Consul.

UNITED STATES CONSULATE,
Glasgow, February 20, 1889.

WALES.

REPORT BY CONSUL JONES, OF CARDIFF.

CANAL CONSTRUCTION.

Three methods have hitherto been observed in the construction of canals:

- (1) The old-fashioned way, by which the sides are made sloping towards the middle, so that the bottom of the canal is very much narrower than the top of the canal.
- (2) The plan by which canals are walled with dwarf walls, protecting the sides, and, to a certain extent, the bottom.
- (3) That by which Canals have complete walls built up the whole of their sides.

The old canals are almost universally of the first description. They are, as a matter of fact, an enlarged ditch, 30 feet wide on the surface, 14 feet wide at the bottom, with a greatest depth of from 3 feet to 5 feet, and inclined slopes on either side. This system of construction caused constant silting, inconvenience, and expense. The Glamorganshire Canal and its branches, the largest and most important canal system in Wales, were built on the old plan. Parliamentary powers were obtained in 1790, and the construction was soon commenced. This canal formerly brought down all the coal of Glamorganshire to the port of Cardiff, and took a large quantity of iron ore and lumber up to the iron works and coal mines of the district which lies inland from the Bristol Channel.

The length of the Glamorganshire Canal is $25\frac{1}{2}$ miles. Its locks can accommodate boats 60 feet long by 9 feet beam, carrying on an average 20 tons. The lower $1\frac{1}{2}$ miles of the canal accommodate vessels of about 300 tons burden. The traffic of this canal, with its Aberdare branch, during 1888 amounted to 660,364 tons; the merchandise handled consisting of coal, iron, timber, corn, flour, and general merchandise.

Canals constructed according to the second plan are an improvement upon the old ones. By this plan dwarf walls go down only partially to the bottom of the canal, say 2 feet or $2\frac{1}{2}$ feet below the water line.

This character of wall is now almost exclusively used, because of the protection given to the sides of the canal, and because it prevents much of the silting up which otherwise occurs.

Canals with complete walls are restricted in length; but those constructed upon this principle are the best, as there is a great saving in the wear and tear of the canal, while it affords greater facilities for steam haulage, if the walling is well done.

CANAL LOCKS.

The sizes of the locks regulate the dimensions of the barges which can navigate a water way; but whereas the deepening of a navigation by dredging may generally be effected at a moderate cost, the enlargement of locks, necessitating in most cases their reconstruction, forms a very important item in the expenditure on the improvement of a water way. The enlargement of the smaller locks for securing uniformity of gauge, and the lowering of the sills of the wider locks, as well as the deepening and widening of the water way to a uniform section throughout, would form an essential portion of any scheme for opening up through canal routes.

EXTENT AND CAPACITY.

Lengths.—The following table shows the lengths of the canals of Wales not under the control of railway companies and under the control of railway companies:

Canals.	Not under control of railway companies.	Under control of railway companies.
	<i>Miles.</i>	<i>Miles.</i>
Canals under 4 miles in length	12½	33
Brecon and Abergavenny		
Glamorganshire and Aberdare	32½	20
Monmouthshire Railway and Canals	14	17
Neath Canal		
Swansea Canal		
Total	58½	70

By the following table it will be seen that the canal mileage of England, Scotland, and Wales amounts to 2,641 miles, the Welsh canals measuring 128 miles:

Canals.	Not under control of railway companies.	Under control of railway companies.
	<i>Miles.</i>	<i>Miles.</i>
Canals in England	1,280½	1,062½
Canals in Scotland	8½	106
Canals in Wales	58½	70
Total	1,403	1,238½

ADVANTAGES OF CANAL CARRIAGE.

Canal carriage is not only superior in the item of cheapness, but it also has the following advantages:

(1) It admits of any class of goods being carried in the manner and at the speed which proves to be most economical and suitable for it, without the slightest interference with any other class.

(2) The landing or shipment of cargo is not necessarily confined to certain fixed stations as is the case on railways; but boats can stop anywhere on their journey to load and unload.

(3) The boat itself often serves as a warehouse in which an owner may keep his cargo till sold.

(4) The dead weight to be moved in proportion to the load is much less in the case of canal carriage than that of railway. The ordinary railway truck weighs nearly as much as the load put on it, whereas a cargo boat will carry four or five times its own weight.

(5) The capacity for traffic is practically unlimited, even in the case of canals with locks, provided the locks are properly designed. A lock 150 feet long by 20 feet broad in a canal with a draft of 6 feet will pass single boats of 300 tons burden. Locks can be designed and are in actual operation which can be operated in 3 minutes. But supposing that time were doubled, then at the rate of 10 lockfuls of 300 tons per hour, the capability of a single lock would be at the rate of $10 \times 300 \times 24 = 72,000$ tons per day or over 25,000,000 tons per annum. If a larger traffic required to be accommodated it would be met by increasing the speed at which the locks were worked.

(6) In the case of either State or private canals, unless worked by the owners of the canal, there is no necessity for maintaining an enormous and expensive apparatus or establishment, as all that can, and would, be carried on by separate agencies and by district capital, thus avoiding a large expenditure in the first cost, and subsequent maintenance of rolling stock.

(7) There is almost total absence of risk, and certainly a reduction of damage to cargo in transit to a minimum in canal transportation. But in order to reap the fullest advantages of water carriage, it will be necessary, just as it is in all undertakings, not only to construct the most perfect instrument possible, but also to take care that it is most carefully and wisely managed afterwards.

CANAL REQUIREMENTS.

The following are among the points requiring attention in canal systems:

1. Improvement in construction.
2. Amelioration of administration.
3. Controlling supervision.

Under the first head are needed—

(1) Uniformity in dimensions of canals and locks, and their adaptation to steam vessels.

(2) Improvement in the models of the ordinary canal-boats.

(3) Facilities for loading and discharging at every important market or industrial center. Administration ought to be exercised by concert and coöperation on the part of the management of canals. The tolls tariffs, dues, etc., ought to be regulated by some definite rule or standard, and ought not to be fixed by legislature according to the influence of the particular companies and the amount the public could be persuaded to pay. The existing canal system in the United Kingdom is faulty, inasmuch as it is divided into so many small companies, each struggling independently of the other, and of course, proportionately weak in their administration.

Rules are wanted for the better regulation of traffic, for systematic and regular boat service, effective maintenance of the boats and haulage power, with a uniformity of tolls.

CANAL VS. RAILWAY TRAFFIC.

Canals are advantageous and, at present, used chiefly for handling wharf-to-wharf traffic and raw-material freight, and for the conveyance of goods where saving of time is not of the first importance. Such products as building stone, chalk, sand, bricks, drain pipes, timber,

grain, pig-iron, coal, patent fuel, etc., are the most suitable for canal conveyance. It would be an advantage to railway companies if they were relieved of some of their heavy traffic, such as raw material, which the canals could carry at much lower rates. Traders, as a rule, make little use of canals because of the delays and uncertainties which characterize the canal system. -

The railways are the great carrying power of the country, but if the canal system should be improved it might profitably carry a much larger amount of traffic than at present. Railways can not be made to deal satisfactorily with all the mineral and other heavy traffic as well as an ever-growing passenger trade, and new lines of canal would be better adapted for the cheap conveyance of heavy goods not in a hurry. The main causes which render transport by canal cheaper than transport by railway are the following:

(a) In canal transport there is no item of cost corresponding to the wear and tear of rails, sleepers, and fittings, or to the replacement and maintenance of permanent way. These items form 13 per cent. of the working expenditure of the railways of the United Kingdom.

(b) A corresponding saving is made in respect of repairs of vehicles and locomotives of railways, due to the damage caused by the reaction of the rigid way.

(c) The maintenance of the works on a canal is, on the average, much less costly than the corresponding outlay on a railway, not only from the absence of vibration but from the much smaller magnitude of the works themselves. The average cost of the railways of England and Wales is £46,000 a mile; that of the canals, as far as it has been ascertained, is not more than £3,500 per mile. The average cost of eighteen of the principal English canals was under £10,000 a mile; that of the Birmingham Canal, of which in 1865 the original £1,000 shares were each worth more than £30,000 in the market, was £15,000 a mile. The cost of the Manchester, Sheffield and Lincolnshire, and of the Lancashire and Yorkshire Railways, which offer the best parallel to the Birmingham Canal, averaged £65,700 per mile. Thus for equal volumes of traffic, the cost of the maintenance of works on a canal will be less than one-fourth of that on a railway. The cost of this item on the railways of the United Kingdom is 7 per cent. of the working expenditure.

(d) The resistance to traction on a level railway at the speed of 30 miles an hour, is exactly ten times the resistance to traction on a canal, at a speed of $2\frac{1}{2}$ miles an hour. The force that will draw a load on a canal at 4 miles an hour is just half that required to draw an equal load on a railway at 35 miles an hour. The economy of tractive force is thus in inverse proportion to the speed of transport. Traction, on the railways of the United Kingdom, costs 16 per cent. of the expenditure. Traction on canals costs half that figure. Out of £200 paid for equal distance the detailed costs are:

Items.	By rail- way.	By canal.
	<i>Per cent.</i>	<i>Per cent.</i>
Maintenance of way.....	13	0
Maintenance of works.....	7	2.3
Repairs of rolling stock.....	19	6
Traction.....	16	8
Traffic expenses.....	30	6
General charges.....	15	15
Interest on capital.....	100	33.
Total.....	200	70.6

Showing an economy of 64.7 per cent. by canal.

When the railway enterprise was at fever heat in this country in the days of Stephenson, canals were entirely neglected by the public, but not by the new railway companies. These corporations recognized a strong competitor in the inland canal, and, as far as possible, bought up the interest. In 1845 the railway companies bought up 78 miles of canal; in 1846, 774 miles; in 1847, 96 miles, making a total purchase in 3 years of 948 miles; and the policy has been so well carried out that the railways have "been enabled in some cases, by means of questionable legality, to obtain command of 1,717 miles of canals, so adroitly selected as to strangle the whole of the inland water traffic."

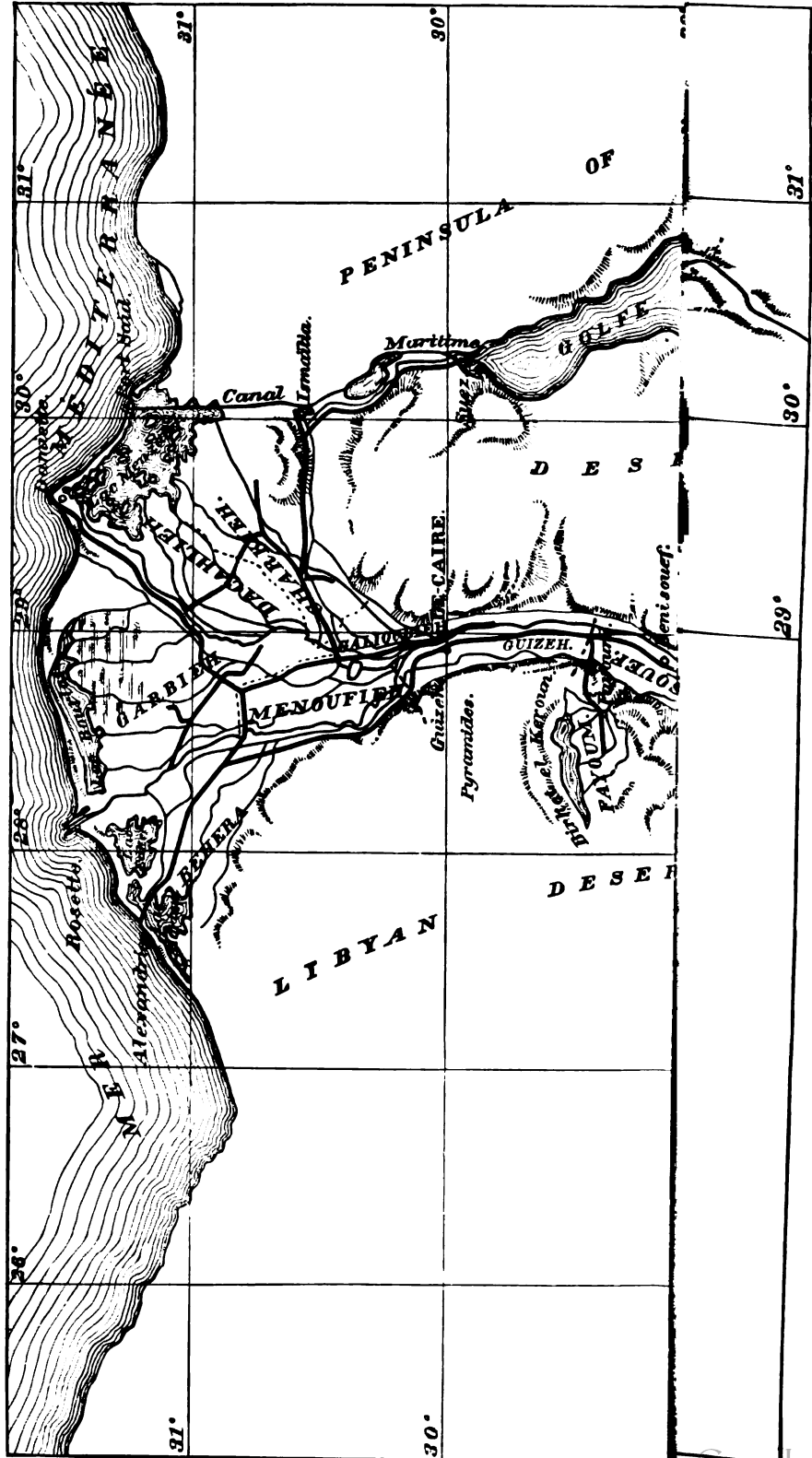
But the period of indifference is over. The public, through Parliament, are alive to the advantages of inland water communication; nor are they likely to permit any further extension of the powers of railway monopoly over the water ways of the country.

EVAN R. JONES,
Consul.

UNITED STATES CONSULATE,
Cardiff, September 17, 1889.

PART II.

IRRIGATION.



CONTINENT OF AFRICA.

EGYPT.

REPORT BY CONSUL-GENERAL SCHUYLER.

In the following report I have abstained from original judgments, and have endeavored merely to give a summary of the systems of irrigation practiced in Egypt, the facts in relation thereto, and the inferences properly derivable. For these I have relied on the excellent work of Mr. J. Barois, secretary-general of the Egyptian department of public works, *L'Irrigation en Egypte*, published by the French ministry of agriculture in 1887 (of which a translation by Maj. A. M. Miller, of the Engineers, has just been published by our own Government), and also on the later and fuller book, *Egyptian Irrigation*, by W. Willcocks, inspector of irrigation in Egypt.

These authorities have been supplemented by the Irrigation Reports of Colonel Sir Colin Scott Moncrieff, K. O. M. G., C. S. I., the under secretary of state for the ministry of public works, and private information derived from officials and other persons. I have purposely omitted engineering and other technical details, which specialists can find in the works just mentioned, and have attempted simply to give an account of Egyptian irrigation which the ordinary reader can understand without too much trouble. The measures have generally (even in the quotations) been transposed into those usual in the United States.

THE NILE.

Although Egypt has been called the classic land of irrigation, and although irrigation has been practiced here from the earliest known times, no records exist of the ancient system except the Nilometers in a few old temples and that on the Isle of Roda, and the representations of the methods of raising water painted or carved on the walls of tombs and temples. Everything else has been swept away either by the Nile itself or by the wars and revolutions that have so often devastated the country.

Irrigation in Egypt is dependent on two things, (1) the peculiar formation of the country; (2) the regular periodicity of the Nile.

(1) Egypt, or more strictly the cultivable land in Egypt, for all else is desert and waste, is composed of two parts: the Nile Valley and the Delta. The long, narrow valley of the Nile, properly so called, extending in a general direction north and south for 559 miles, from latitude 24° north to 30° north—from Assouan to a few miles north of Cairo—is scarcely wider in any place than 15½ miles, and once or twice draws close to the river, but has an average breadth of from 7½ to 8½ miles. This is called Upper Egypt, and contains about 2,400,000 acres

of cultivable land, of which 2,215,000 are cultivated and pay taxes. The general slope of the river water is 4.68 inches per mile.

Among the Libyan Mountains, about 56 miles south of Cairo, is an opening, and behind this a depression, nearly circular, about 25 miles in diameter, called the Fayoum. It is watered by a canal brought from the Nile. In one part of it existed in old times what was known as Lake Moeris. The land at present cultivated in the Fayoum amounts to 220,000 acres, besides 60,000 acres more that could be reclaimed. This oasis forms part of Upper Egypt.

Just north of Cairo the river divides. Formerly there were seven main branches, though not as late as the time of Strabo; but now there are only two, although the older ones are to some extent represented by canals. A triangle of cultivable land is thus formed about 100 miles long by $87\frac{1}{2}$ miles at the base on the seashore. This is called the Delta or Lower Egypt, and contains a cultivable area of 4,000,000 acres, 2,740,000 of which are at present cultivated and pay taxes.

The slope of the water of the Nile in the Delta is 2.62 inches per mile. In other words, the level of cultivable land at Assouan is 308 feet $1\frac{1}{2}$ inches above the level of the Mediterranean, and at the point of the Delta 55 feet $9\frac{1}{2}$ inches above the Mediterranean.

According to the census of 1882 the total sedentary population of Egypt is 6,302,336, representing 543 inhabitants per square mile, while that of Belgium, the most densely populated country of Europe, is only 530 inhabitants per square mile.

Upper Egypt is practically a rainless country, the annual amount of rainfall being only 1.056 inches. In the Delta the rainfall is 8.365 inches. The evaporation is of course very much greater, being estimated to be, taking the average of the year, at 0.197 inch per day for Upper Egypt and 0.079 inch per day for the Delta, thus giving 71.9 inches as the evaporation for 1 year in Upper Egypt and 28 inches as the evaporation for 1 year in Lower Egypt.

(2) The regularity and the periodicity of the Nile. The Nile proper begins at Khartoum, at $15^{\circ} 40'$ north latitude, by the union of the two great equatorial rivers called the White and the Blue Niles. The river a little south of Berber, $15^{\circ} 40'$ north latitude, is joined by the Atbara, which is more a torrent than a river, for it is dry during several months; but in the proper season it brings down the waters of the northern mountains of Abyssinia. From that point to the Mediterranean, a distance of about 1,687 miles, the Nile receives no water from other sources.

The bed of the Nile is a trench cut in the strata of mud which it has brought down for so many years. Sometimes for a long distance it is quite straight, at others, however, it is tortuous, and it frequently changes its course. In Upper Egypt the river has a tendency to push itself towards the east, sometimes running close under the rocky cliffs which bound the valley, so that most of the cultivated land is on the left or western bank.

The width of the Nile is variable. At low water it runs between sharply cut banks and shoals of sand and mud, and is often divided into various channels. Its level at that time is from 26 feet 3 inches to 32 feet 10 inches below the surface of the soil near Assouan, and from 16 feet 5 inches to 19 feet 8 inches below near the point of the Delta. After midwater the river is about even with its banks, varying in width from a third of a mile to $1\frac{1}{4}$ miles, and is even separated into branches by islands sometimes several miles long. It is narrowest opposite Cairo, where its width is reduced to about 787 feet. At high water, especially during a great rise, it would cover the entire valley were the land not

protected by dikes running the whole length of the banks of the river. The branches of the Nile, which include the Delta, have very much the same irregularities as the main stream.

Every year the Nile begins to rise in Egypt at the end of June and continues to increase until the end of September. Afterwards the water falls rapidly at first, and then slowly until the following June. This phenomenon is reproduced every year with some variation in the levels of low water and flood and in the days of maximum and minimum. In Egypt there is no reason to fear those accidental and unforeseen floods or freshets, which cause so much damage in Europe and America.

The regularity of this annual rise is due to the fact that the Nile is fed slowly by periodical tropical rains, and that it is not disturbed by the accidental rains which occur in other countries. The great equatorial lakes begin to send the overflow of their water to the Nile through the Bahr el Gebel in April. The rains then pass northward and fill two other great rivers, Sobat and Bahr el Gazelle, which keep up the rise produced by the Bahr el Gebel.

The White Nile rises at Khartoum at the beginning of April and again near the end of August; this movement continues and sustains the river until September. The floods begin to show at Assouan in June, about 40 days after the rise at Khartoum. The Blue Nile and the Atbara, which bring down the mud from the plateau of Abyssinia, only reach their maximum in August, and thus arrive at Assouan in September. The great swamps along the course of the White Nile and the valleys and ravines below Khartoum act in a way as regulators and prevent a sudden influx of water. As there is a difference more or less great every year in the rise of the Atbara, the Blue Nile, and the White Nile, there are variations which render the utilization of the flood water more or less difficult. At Assouan—that is to say, the beginning of Egypt—the limits within which these annual changes can occur are as follows:

First. The maximum flood is nearly always between August 15 and October 1.

Second. During the 10 years from 1872 to 1881 the level of the lowest water varied between 276 feet 5 inches to 285 feet 3 inches above the Mediterranean, giving an extreme variation of lowest water of 8 feet 10 inches.

Third. During the same time the highest flood levels varied between 300 feet 1 inch and 309 feet $1\frac{1}{2}$ inches, showing an extreme difference of 9 feet one-half inch.

Owing to certain irregularities in the counting of the rise by the nilometer on the island of Roda, opposite Cairo, the rise of the Nile is best shown by the nilometers at the Barrages, a few miles north of Cairo.

The possession of Khartoum and Berber was of great use to Egypt in one way, because the rise was marked by the nilometers there and was at once telegraphed to Egypt, and as the waters took 40 days at the beginning of the flood and 30 days at the end to go from Khartoum to Assouan, it was possible to keep the dikes and canals in perfect readiness. At present the first nilometer is at Wadi Halfa, on the extreme southern frontier.

The nilometer at the Isle of Roda, opposite Old Cairo, was established in the first century of the Hegira, and consists of an octagonal column placed on a base in the middle of a well, the bottom of which is of masonry. As the Nile rises the water percolates through the sides of the well and its height is marked on the column. This nilometer

was carefully studied by the French expedition, and on several occasions since the well has been pumped dry and the various marks for measurement on the column and on the sides of the well have been carefully noted. The zero of the scale is at the height of 28 feet 6½ inches above the mean altitude of the surface of the water of the Mediterranean. The average length of the *pic* or ell on this nilometer is 0.5404 metre (21.29 inches).

When the water has risen to the sixteenth ell mark (which is really the seventeenth, because the first ell is not marked) the *wafa* is proclaimed, that is, the rise necessary to irrigate the whole country. By an old custom, which has been observed by public measures from father to son since the ninth century of the Hegira, from this point until the end of the twenty-second *pic* the old measurement is not used, but only half of it, *i. e.*, 0.27 metre (10.638 inches); from the beginning of the twenty-third *pic* onward the old *pic* of 0.5404 (21.29 inches) is again used.

The nilometer at Assouan was established in 1870, and the invariable measurement of the *pic* of 0.54 metre is used. Mahmoud Pasha Falaki carefully measured the antique nilometers on the island of Elephantine, and in the eastern corridor of the temple at Edfou, and found the *pic* or ell marked on them both to be exactly 0.53, and not 0.525, as had been previously supposed. With the assistance of Mr. Brugsch he also carefully measured those parts of the Temple of Edfou, the measurements of which were given in the old texts, and found the *pic* or ell measurement to be exactly the same, 0.53 metres.

Mr. Willcocks says:

The following observations about the course of the Nile are interesting. Lake Victoria lies about 3,769 feet above sea level, and is 1,642 feet higher than Lake Albert, the White Nile having traversed in this interval, first the great Ibrahimia Swamp and then a succession of rapids culminating in the magnificent Murchison Rapid. While the temperature of the country near Lake Victoria is similar to that of Alexandria and all the tribes are well clad, at Lake Albert we reach the stifling heat of Central Africa and the completely naked tribes. It is unfortunate that the survey of Lake Albert was made by Mason Bey in 1877, when there was a complete absence of rain, and the channel connecting this lake with the great lakes lying to the south of it was not navigable. The White Nile leaves Lake Albert at 3,187½ miles from the sea. At 3,062½ miles from the sea are the Fola Rapids, up to which, in Gordon's opinion, it was possible to come from the sea in steamers, but absolutely impossible to pass it.

Between Gondokoro, 2,875 miles from the sea, and the mouths of the Gazelle River, 2,437½ miles from the sea, lies the region of "saddles," or dams of living vegetation, which completely block the river, and during flood make this swamp act as a natural regulator of the Nile. It is a strange fact that between 1870 and 1880, *i. e.*, during the time these "saddles" were cut and the river kept fairly open, have occurred the very highest and lowest floods of which there is any record in Egypt; though the openings themselves were not very considerable. The Bahr el Gazelle has a feeble discharge, and acts rather as a reservoir than as an affluent. At 2,375 miles from the sea the Sobat River flows into the White Nile; this river has a discharge equal to that of the White Nile above the junction, and it is not surprising that the drying up of this stream in the summers of 1859 and 1860 resulted in very low supplies at Cairo during those two years.

The catchment basin of the Sobat is about 57,915 square miles. Its waters are milk-white,* and it is the addition of the white waters of the Sobat which causes the name of "white" to be given to this branch of the Nile at Khartoum. North of Fashoda the right bank of the river is as carefully cultivated as the Delta, and supports a dense population; the soil, however, is light colored, and lacks the rich dark-colored deposit brought down from Abyssinia by the Blue Nile. The waters of the White Nile, which below the junction of the Sobat are milk-white, above the junction are generally green and unhealthy from the terrible marshes just traversed. From Fashoda to Khartoum the river is a broad, deep, sluggish stream, with a perpetual set on to the right bank. This set on to the right bank is continued as far as the sea.

* Mason Bey says that they "are beautifully clear, like those of the Blue Nile or the Rhone."

At 1,875 miles from the sea, and at a height of 1,313½ feet above it, is situated the town of Khartoum, where the Blue Nile from Abyssinia joins the White Nile, and the river is henceforth known as the Nile. The Blue Nile is comparatively clear during winter and summer, but during flood, i. e., from the 1st of June to the 31st of October, it is of a deep reddish-brown color, heavily charged with alluvium. The Khartoum Nile gauge used to stand in the Blue Nile, about 3 miles above its junction with the White Nile, and was therefore no exact record of the river.

At the beginning of the flood the velocity of the Nile is about 1½ miles per hour. In full flood the velocity is 3½ miles per hour.

Mr. Willcocks gives the discharges of the Nile at Cairo and at the Barrages per 24 hours as follows:

Locality.	Channel.	Season.	Discharge in cubic feet per 24 hours.		
			Maximum.	Minimum.	Mean.
Cairo.....	Main Nile	Summer	2, 189, 840, 000	883, 000, 000	1, 200, 880, 000
Do	do	Flood	36, 450, 240, 000	16, 423, 800, 000	24, 017, 600, 000
Do	do	Winter	7, 064, 000, 000	3, 178, 800, 000	4, 591, 600, 000
Barrages	Rosetta branch	Flood	19, 849, 840, 000	9, 536, 400, 000	13, 421, 600, 000
Do	Damietta branch	do	14, 304, 610, 596	5, 208, 000, 000	8, 476, 800, 000

During summer and winter the Barrages are regulated and the supply sent down the two branches is variable. Finding the mean winter discharge is a complicated operation, as there is the very greatest difference between one year and another, and between the beginning and end of the winter itself.

The mean *daily* discharge of the Nile at Cairo is estimated therefore at about 8,830,000,000 cubic feet. The mean *annual* discharge has been estimated by different persons between 3,284,760,000,000 and 3,814,560,000,000 cubic feet.

The analyses of the soil and of the Nile water* differ so considerably that it is difficult to draw any accurate conclusion from them. The analysis made in Paris in 1872 is in some respects contradictory to that made by the French savants at the beginning of the century. That made by Dr. Letheby month by month in 1874-'75 is still different, but he unfortunately experimented on the mud brought down by a very high Nile, which was not as rich as usual. The analysis depends, as Mr. Willcocks says, on whether—

The specimen experimented on is old or recent, has been deposited during a high or low flood, and as the locality from which it has been taken is near to or far from the river. Nile mud, however, always contains a moderate amount of carbonates of lime and magnesia, oxides of iron and carbon, disclosing the existence of decomposed organic matter, and a considerable amount of volcanic detritus. It is to the volcanic plateau of Abyssinia, where Lake Dembea itself, the reservoir of the Blue Nile, looks like an ancient crater, that Egypt owes the main part of its rich deposit; while to the great swamp regions of the White Nile it is indebted for its organic matter, and to the basin of the Sobat River, probably, for its lime. Between them these constituents form a soil difficult to surpass by any artificial mixture of valuable ingredients.

It is important to notice that whenever a well is sunk in Egypt, and especially in some parts of the Delta at a certain distance from the Nile, through the layers of alluvium down to that of infiltration, the water is entirely different from that of the Nile, and is generally brackish. This is shown by the whitish efflorescence, and sometimes by real deposits of salt, which render cultivation impossible.

The soil of Upper Egypt [says Mr. Willcocks] and Lower Egypt down to a contour of 23 feet above the Mediterranean, is practically free from salt in excess, except where very high lands are being perpetually irrigated by lift and never washed by a flood.

* According to Mason Bey, the fellahs divide the floods into two categories, male and female. A male Nile is when the waters contain an excess of sand; a female Nile is when argillaceous matter is prominent.

Below a contour of 23 feet, however, bad drainage is always accompanied by salt efflorescence. Below a 10-foot contour salt is everywhere in excess, and the land needs very careful drainage and frequent washings. Below a 5-foot contour the land has practically still to be reclaimed.

Hence the statement of Sir Colin Scott Moncrieff that "the Delta needs rather to be drained than to be irrigated."

SYSTEMS OF IRRIGATION.

From the earliest times two different systems of irrigation have been practiced in Egypt; the basin submersion, or inundation system, and the ordinary method of irrigation by means of canals and ditches. But up to the early years of this century the latter was the exception, and the basin system was the usual and common method. Mehemet Ali began to suppress the basins in the Delta and dug canals, so as to let on the fields the water of the Nile when low, in order to raise spring and summer crops, and this example was followed by his successors, chiefly with a view to the cultivation of cotton. The Khedive Ismail partly introduced the ditch system into Upper Egypt, so that at the present time inundation basins cover less than a third of the cultivable land in the country. But, as the Nile at low water has little suspended fertilizing matter, competent hydraulic engineers claim that the prosperity of the country demands a return to the basin system in the Delta under restrictions and regulations.

THE BASIN OR FLOOD SYSTEM.

The basin system of submersion could not be applied to all rivers. It is successful on the Nile, because the alluvium brought down is always gradually raising its bed, and causes a gradual slope from the banks to the desert hills. Its essential elements here are—

- (1) A dike along the bank of the Nile high enough to protect the land from direct inundation during the flood. This dike serves to raise the waters in the basin to a level higher than that of the river at the point opposite. Except in very high Niles these banks serve to prevent the water flowing into the river.
- (2) Transverse dikes bounding and separating the basins from the Nile dike to the hills, or to another dike parallel to the Nile.
- (3) A canal above to fill the basins, and another below to empty them.

Some of the basin systems are extensive, and often connect with other systems. The entrance of the Nile water into the canal and from the canal into the basin is regulated by gates protected by strong masonry. The plan hitherto followed has been to let the water into the first basin, and when it has obtained a sufficient height, to open the regulators of the next basin, and so on. From the last basin the water is returned to the river. In case of a sudden flush it is sometimes necessary, in addition to opening the gates, to make temporary breaches in the Nile dike, which have to be repaired before the next rise of the river.

One disadvantage of this way of working the basins is, that the upper basins get an undue share of the fertilizing mud suspended in the water. There was a striking example of this in 1885. The basin of Kosheisha, in the province of Beni-Souef, had usually received its water after the mud had been well exhausted in basins above it, and the crops were generally small. In 1885 the Nile dike broke when the river was at its height, and the *red water* (the most fertilizing kind) covered the

land. The crops were so fine after this accidental inundation that the land-owners asked for and obtained the direct introduction of the Nile into their basin. Another disadvantage is that in case of a low Nile much land may be left without water, and thus thrown out of cultivation the next year, to the great detriment of the cultivators and also of the treasury in diminishing the land tax.

The English engineers propose to remedy this by constructing high level canals parallel to the Nile, which will let water simultaneously into all the basins of a system. This subject was well treated in a report on the prevention of damage from low Nile floods, inclosed in my dispatch No. 30, dated December 4, 1889.

The Nile water is introduced into the basins when it is at its highest and contains most fertilizing matter in suspension, which has been estimated at 0.09 pound per cubic foot of water.

After allowing for evaporation and leakage a good submersion required about 200,000 cubic feet of water per acre, *i. e.*, the water should have a mean depth in the basins of 4 feet 7 inches. The water should remain on the land for sixty or seventy days if possible.

Generally the basins begin to fill in the first fortnight of August, and are emptied during October. It is estimated that the deposit of fertilizing mud left is 6.244 tons per acre, or a stratum of about 0.039 inch thick, if uniformly spread. The water exercises another important influence which contributes to the fertility of the soil, for after the water has run off the ground cracks into deep fissures, and is then subjected to a perfect aëration.

The regulation of the basins is far more complicated than might at first seem, because the division of the water in the different basins has an important influence on the crops, and while it is easy enough to inundate the low lands, it is necessary sometimes to hold back the water for the high lands. Much depends on the rise of the Nile.

If the rise be earlier than usual, the water penetrates too soon into the basins by infiltration or otherwise. Crops at lower points, which have been watered with great difficulty by wells or otherwise, are submerged before ripening or being gathered.

If the rise be late, the sowing after the basins are emptied is similarly delayed, and the crops are exposed to the strong heat of the following spring.

If the rise be not great enough, the high lands get no water or not enough, and are thrown out of the cultivation, or the basins get too little, to the damage of the subsequent crop. If the rise be too high, the dikes are threatened and require increased watching and care. If the rise last too long, there is still water in the feeding canal at the proper time for emptying the basins; these are emptied slowly, and the land stays wet too long.

These difficulties of management, and the frequent connection of one basin system with another, render it impossible to leave the control of irrigation here in private hands. No one but the Government can be properly responsible for it.

One advantage of the basin system is that it prevents damage from a very high flood. The surplus waters are stored behind the dikes and thus form vast lakes, much greater than the Nile itself. Fortunately the season of inundation corresponds with the complete absence of any growing crop in the basins of Upper Egypt. During the flood, from August 12 to October 10, the Nile Valley is one vast lake.

CANAL IRRIGATION.

The canal irrigation system, although it exists to some extent in Upper Egypt, especially through the Ibrahimieh Canal and the Bahr Yussef, is chiefly confined to the Delta. Even the Delta up to the early part of this century had the basin system also, but Mehemet Ali, seeing the great advantages which would accrue from the cultivation of cotton and other crops during summer, dug what are called summer canals so deep that they are filled by the water of the Nile even at its lowest. The water of course must be raised to the fields by pumps and similar machinery.

The basins existing up to that time had been filled not only by the two branches of the Nile and some secondary arms, but by broad canals. These were utilized and made deeper in order to bring the low water, being in some cases 27 feet 10.9 inches below the surface of the soil, but the contour map of the Delta is very puzzling, because, as in Upper Egypt, the land slopes gradually from the river to the desert; so in the Delta it slopes both from the banks of rivers and from the banks of the canals towards the interior of the country or what might be called the islands. There are a number of independent systems which may be thus described:

(1) A feeding canal, coming from the Nile, divided into several mill races, as it were, by regulators at the head of the chief branches, which provide water all the year round.

(2) Secondary canals, coming from the chief canals sufficiently deep to be fed even during low water.

(3) Other secondary canals not so deep, which receive only the flood water. These are beginning to disappear and to be replaced by deep canals.

Flood canals are now made parallel to the main summer ones, the latter not being filled in flood, to avoid silt.

(4) A draining canal, which is properly the lower termination of the feeding canal, ending in the lakes and swamps in the north of the Delta. Generally it receives the overflow of the feeding canal, for the drainage of the lands has been greatly neglected and must be improved before such lands can produce to their full value. These canals have generally slopes of from 0.21 to 0.26 inch per mile.

WATER LIFTING.

It is only at the time of flood that it is possible to irrigate land directly from the Nile without resorting to water-lifting appliances. These are for the most part rude and simple, especially in Upper Egypt.

When the lift is less than 40 inches and where, owing to the fluctuating supply, flush flood is frequent, the usual apparatus is the "nattal." This is a closely woven palm-leaf basket with two ropes at each side, held by two men standing on the water's edge or sometimes half seated on a platform on the lower bank. They swing this in such a way as to fill it with water and throw it into the mouth of a small ditch, which carries it over the fields. By this process two men can raise from 140 to 175 cubic feet of water per hour. This has the advantage of being easy, inexpensive, and applicable anywhere in proper conditions.

When it is necessary to raise the water more than 40 inches this becomes fatiguing, and the "shadoof" is resorted to. This is perhaps one of the oldest methods of raising water, being found not only in Russia and throughout Asia, but even in America, where it is called

the old well-sweep of New England. The bucket, or in this case the basket, is attached to a pole, the lower or farther end of which is heavily weighted by clay.

The machinery rests on a mud platform built in the bank, for the clay or mud of the Nile is so plastic that it takes any form, into which it dries very solidly.

The water is taken not only from the Nile itself, but from a small well or basin dug into the bank into which the Nile water flows. It is often necessary to have two, three, and even four stories of "shadoofs," one above the other, though not directly so, for the water thrown up by the first empties into a little ditch which leads to the second basin. From this it is pumped into a third and then into the canal, irrigating the fields. While the apparatus is very cheap the work is slow. A man averages only about 10 baskets or 22 gallons a minute, that is 211.90 cubic feet per hour. The relays of men are changed every 2 hours. It is estimated that when the bank is sufficiently low to allow of "shadoofs," two men will water an acre and a quarter per day. Numerous interesting observations were made as regards "shadoofs" by the French expedition under Bonaparte, and it was estimated that the work done by one man with the "shadoof" was on an average 330 kilogrammetres a minute, while the dynamic action of a man of ordinary force working with a cord and pulley, by which he raises a bucket full and lets it down emptied is only 213 kilogrammetres.

Of the different sorts of wheels for raising water the most common is the "sakieh" or Persian wheel. This consists simply of a vertical wheel, carrying an endless chain of small earthen pots placed at about a foot from each other, which descends into a rude well on the bank of the Nile, thus bringing up the water and pouring it out into a trough leading into a canal. This vertical wheel is turned by another horizontal wheel applied to it by a rude system of uneven cogs, itself turned by a cow or a buffalo harnessed to the end of a long lever. The "sakiehs" are sometimes used in wells in the middle of fields, where such exist, and their existence is known at a long distance by the groaning sound produced by the creaking cogs which has sometimes the effect of a plaintive song. A "sakieh" is supposed to equal 4 "shadoofs" and will irrigate 5 or 6 acres. Under the usual conditions it is necessary to employ 3 buffaloes and 2 men.

According to the experiments of the French expedition, each jar of the "sakieh" holding 1.41 quarts and weighing 2.2046 pounds, the amount of water delivered by the "sakieh" would vary from 925 to 1,200 gallons of water an hour, according to the height of delivery, sometimes as much as 36 feet; but its delivery is very uncertain, both on account of the coarseness of the mechanism and the height at which the water is delivered. A good horse working a "sakieh" at a height of 10 metres (32½ feet) produced only 718 kilogrammetres per minute, while in Europe the power of a horse harnessed to the machine is estimated at 2,430 kilogrammetres per minute. Therefore, although the "sakieh" is very inexpensive it is uneconomical as a means of raising water, and can be used only on account of cheapness of labor. In the districts of the Delta between the branches of Damietta and Rosetta the land is estimated at 1,235,500 acres, and there are 12,000 "sakiehs," which would give about 28,000 for the whole of the Delta.

In the northern part of the Delta, where the water is to be raised more than 10 feet, wheels called "taboots," are used, which are deep in the water and bring it up in the hollow rim of the wheel itself and let it out through side openings.

In the Fayoum, where some of the canals have considerable slope, thus making a fall, it has been found possible to use something in the nature of an ordinary undershot water-wheel carrying earthen jars attached to its periphery.

It is curious that although either the north or the south wind blows almost constantly in Egypt windmills are not used as a means of pumping water, it being thought that the velocity is insufficient. On the contrary, steam pumps have been introduced in various places.

The engines are generally portable and the pumps are centrifugal, owing to their great convenience and power to resist wear and tear. They are generally 8-horse power engines and their fuel is ordinarily coal, which has to be imported, though cotton stalks are sometimes used, while in Upper Egypt, where coal is too dear, wheat straw and bean straw are used as fuel. A discharge of 16,953 cubic feet per nominal horse power per 12 hours is the mean in Egypt. This is very small, but many of the engines are completely buried under water during every flood, while the pumps are very badly treated and scarcely ever repaired, except when almost too late. It is a wonder that they have not long ago yielded to the competition of the cheaper "sakieh." The number of such portable engines and pumps throughout the country is estimated by Mr. Willcocks at 2,200, without counting about 400 fixed pumps tolerably well looked after and in good order.

The regulations for the installation of pumps worked by steam or waterfalls are very rigid, as also are the rules for cutting dikes for letting water into one's fields. But these regulations have apparently been made to be disobeyed, and very few of the steam pumps of the country have been put up with the proper authorization of the Government.

EXISTING IRRIGATION WORKS.

(1) *The Nile dikes.*—The Nile throughout its whole course is kept in by dikes high enough to stand the greatest floods. These have been made out of the alluvium, and therefore have a ditch or canal running alongside of them from which the earth was taken. Their distance from the river is variable, and therefore there sometimes are very large tracts of cultivable land between them and the river. It is difficult now to understand the local reasons which may have caused the dikes to be built in this way, but we must believe that they followed what was the greater bed of the Nile many centuries back.

The type of the dike is nearly always the same. The crest is about 13 feet wide at the top, the height about $3\frac{1}{2}$ feet above the highest flood, and the profile 1 foot high and 3 feet wide. Permissions are given to make cuttings in the dikes for watering certain lands, and although this might be considered hazardous it is seldom that any real danger arises from it, as the attention of the population is always called to these points. The danger of the dikes generally comes from the current which strikes them at an angle, or from whirlpools and backwater.

It was formerly the custom to strengthen the dikes during the inundation at the threatened points by throwing in heaps of stones; but in this way much material was wasted without great result. At present small spurs or jetties of stone are built out above the menaced points and the portion below is filled in to some extent with branches and logs and other matter, so as to provoke the deposit of alluvium, and thus a greater fixedness has been given to the bed.

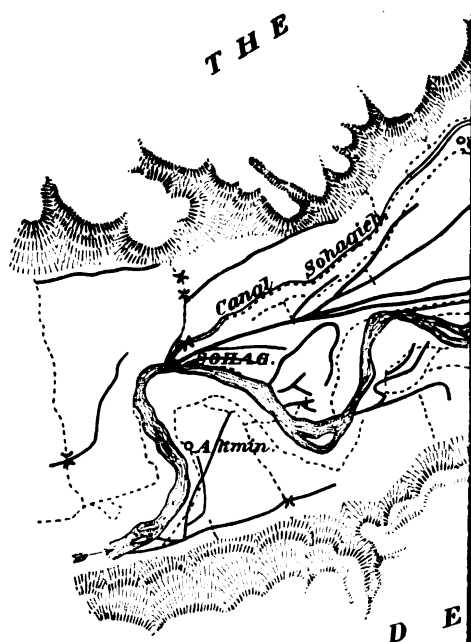
It is estimated that about 3,532,000 cubic feet of stone are used annually for protecting the bed of the Nile.

REFERENCE.

———— Canals, Water Courses.

----- Dikes.

✕ Reservoirs.



(2) *Basins of Upper Egypt.*—Of these there are about twenty-one different series, one of which has as many as twenty-one basins. Mr. Willcocks says:

There are altogether 103 basins on the left bank in Upper Egypt, covering an area of 1,174,022 acres, while on the right bank there are 62 basins, covering an area of 288,392 acres. There are therefore altogether 1,462,414 acres in 165 basins, with a mean area of 11,400 acres per basin on the left bank, and 4,650 acres per basin on the right bank, or for the whole of Upper Egypt a mean area per basin of 9,000 acres. Of the balance, 461,586 acres are under summer irrigation on the Ibrahimieh Canal and in the Fayoum, and 291,000 acres are under flood irrigation on the siphon canals. Two of the largest basins in Upper Egypt are Delgawi, at the tail of the Sohagieh system, and Koshésha, at the tail of the Bahr Yusef system; the former contains 48,000 acres and the latter 40,000 acres. The smallest basin is possibly Maâsra, on the right bank of the Nile in Ghizeh province, with only 500 acres.

A fair example of these systems is the Sohagieh system on the canal of the same name, which has twenty-one basins, covering 261,167 acres, three of them being from 38,000 to 48,000 acres each. The canal is 93 miles long. It has a masonry regulating head with twenty-one openings, 10 feet wide each, built in 1873. As far as the Beni Smia basin it has dike banks like the Nile, and the infiltration water in the summer is sufficient for the lift irrigation of the sugar-cane fields; beyond this it simply runs through its basins without any bank. Near the head the bed width of the canal is 230 feet, the level of the bed 158½ feet, and the ordinary flood level 201 feet, with a maximum discharge of 1,412,800,000 cubic feet per day and an ordinary mean discharge of 1,059,600,000 cubic feet. This canal never silts. The whole system is discharged into the Nile by the cut in the longitudinal bank of the Beni Smia system at Aboutig and by two escapes in the longitudinal bank of the Zenaar basin south of Assiout. The villages are generally constructed within the basin, and in order to avoid inundations raised on mounds connecting with the bank by a narrow dike.

These three provinces of Upper Egypt, Esneh, Keneh, and Girgeh, where the irrigation is chiefly the basin system, have a surface of 785,778 acres cultivated. The amount of earth moved, up to the recent changes made by the English engineers, was annually 125,386,000 cubic feet for the canals, in all 289,614,000 cubic feet, which cost annually \$569,000, being an annual movement of over 36,422 cubic feet per acre, at an expense of 72 cents per acre.

(3) *Ibrahimieh Canal and its branches.*—This canal, of which the main line is about 168 miles long, begins at Assiout and irrigates the left or western bank of the Nile and the provinces of Minieh, Benisouef, and Fayoum, in all 1,062,530 acres. Of this amount about 593,000 acres are inundation basins on the branch called the Bahr Yusef, and, in order to favor the better situated lands where sugar-cane is grown, no summer irrigation is allowed there. It was completed in 1873. It takes its rise in the Nile without any regular works, the mud banks being simply incased with masonry for about two-thirds of a mile.

The original bed width of 115 feet being quite insufficient for a depth of water of 26½ feet during flood, and there being no regulating works at all for the first 38 miles, the severe scour has yearly brought down the banks and increased the bed width to 197 feet. The material thus brought down chokes up the bed, which has to be cleared yearly, at a cost of about \$125,000, and it is also necessary to protect the railway running along the bank from being eaten away by the water. The amount of silt to be thus cleared away averages over 24,759,320 cubic feet during the first 38 miles. From this point, Deirut, there are three branches—the Sahelieh Canal, running for about 25 miles between the

Ibrahimieh Canal and the Nile, irrigating the highlands; the Deirut Canal, about 73½ miles long, which irrigates the western side, and the Bahr Yusef, which will be spoken of presently. This canal discharges at Deirut as follows:

	Cubic feet per second.
Ibrahimieh above Deirut:	
Summer	183,664,000
High flood	3,108,160,000
Winter	529,800,000
Ibrahimieh below Deirut:	
Summer	116,556,000
Flood	388,520,000
Winter	148,344,000
Bahr Yusef Canal:	
Summer	45,916,000
Maximum possible in flood	1,130,240,000
Ordinary maximum in flood	553,640,000
Winter	105,960,000

The Deirut escape discharges as a maximum 1,200,880,000 cubic feet per second in flood.

Besides Deirut there are three other escapes.

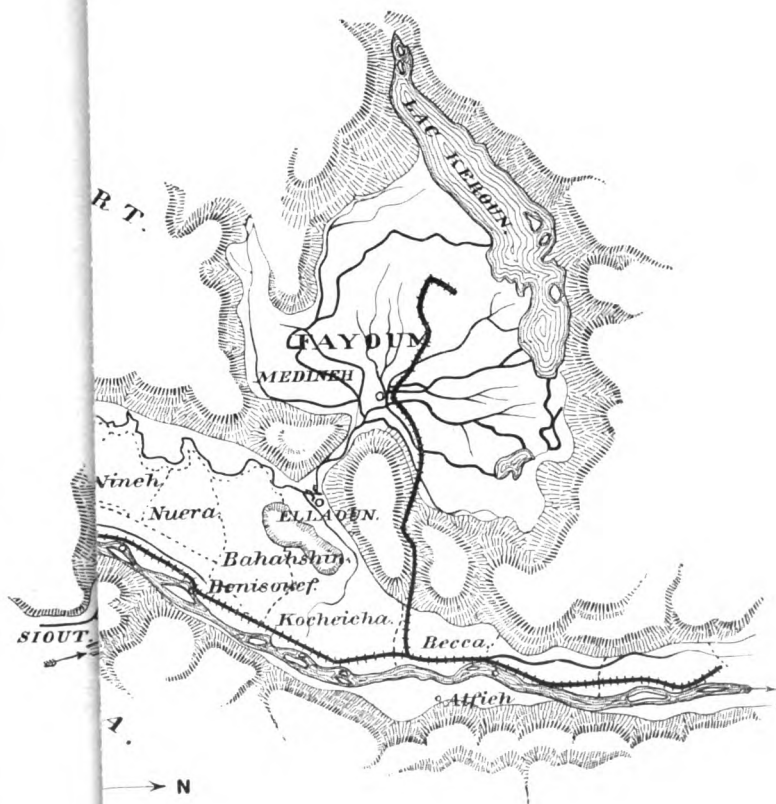
Mr. Willcocks says with regard to the effect of the Ibrahimieh Canal:

In the Minieh and Beni-Souef provinces the Ibrahimieh Canal irrigates not only the highland near the Nile, but a long strip of land taken from the basins. The new longitudinal bank, with its deep pits and stagnant water, is a running sore through the length of the tract, doing infinite harm. It will be noticed that the water surface in summer is nearly as high as in flood at the regulators below Deirut; this is coupled with the fact that the land traversed by the canal is in great part light and sandy, owing to its position near the Nile, and that owing to the total absence of rain the land is never washed.

These three factors between them are combining to destroy the country irrigated by the canal. Salt efflorescence is very greatly on the increase; coarse grasses are overrunning the ground in many places; beginning at the Beni-Souef province, sugar cane is being abandoned for cotton, which is not ruined by salts to the same extent as sugar-cane is; the winter crop does not yield half what it did some 15 years ago; while some 10,000 acres of the best land in Egypt have been thrown out of cultivation and converted, partly into a salt plain and partly into a marsh. All this since 1873, i. e., in 15 years. The liberties which are taken with nature, in Lower Egypt, and which bring their punishment slowly, bring speedy retribution in Upper Egypt, where the summer heat is excessive. A system of extensive draining and washing in winter may do something, but the only real remedy is a lowering of the water surface and the putting one-fourth of the land every fourth year in rotation under basin irrigation.

The Bahr Yusef was originally a natural water course which took its rise in the Nile at Deirut, where its old bed is crossed now by the Ibrahimieh Canal. It is supposed to take the name from the Joseph of the Scriptures. It is very tortuous in its course, but according to its general direction it is about the same length as the Ibrahimieh Canal below Deirut. During low water it discharges about 600 cubic feet a second, and at flood, when the basins are being emptied, it discharges at least 30,022 cubic feet per second. At that time it is used for filling thirteen basins which lie on its course, the last of which discharges into the Nile. These series of basins are too long, so that the lower ones receive water without much fertilizing mud, and it is necessary to make some improvements. The last dike binding the lower basin differs from all others in Egypt, not being constructed simply of mud, but being faced on both sides very solidly with masonry.

After a course of 197 miles the Bahr Yusef leaves the bed of the Nile and goes through a depression in the Libyan Hills at Lahoun, about 3¾ miles wide, through a very ancient bank of great height and width, which was revetted with masonry in 1885. This bank separates the Oasis of the Fayoum from the Nile Valley. A course of 13¾ miles



brings this canal to the town of Medinet-el-Fayoum, the ancient Arsinoë, where it is divided into fourteen canals which irrigate the whole of the oasis, the only one in connection with the Nile. The cultivated area of this district is 220,000 acres, but 80,000 acres more which were formerly cultivated could easily be reclaimed, and the depression southwards across another slope, discovered a few years ago by Mr. Cope Whitehouse, would allow not only a great amount of water storage but a great increase of cultivated land. The level of the Fayoum is so much below that of the Nile that it is possible to irrigate the fields by means of undershot water wheels carrying buckets, and there are two hundred and fifty flour mills worked by turbines and other water machinery.

The water carried by the canals of the Fayoum is discharged into the Lake Kurun, the level of which has so much risen in consequence of the surplus of water as to swamp much of the surrounding land. Through the efforts of the English engineers the level of the lake has been greatly reduced.

4. *The Ismailieh or Sweet Water Canal.*—In Lower Egypt the Ismailieh or Sweet Water Canal deserves special notice, because it was dug in recent times all at once, and it is therefore far more regular than any of the others. It was intended partly to convey sweet water to Suez and Ismailieh, and partly for the purpose of making a navigable canal (in accordance with an agreement made with M. de Lesseps and the Suez Canal Company) to Lake Timsah where it meets the Suez Canal. It is 100 miles long, the branch to Suez being 55½ miles more, and follows in general the lines of the ancient canals connecting the Red Sea with the Nile. It starts from Cairo itself, being fed from the Nile at the bridge, although this feeder is now not used, and again by a large lock at Shoubra one of the suburbs of Cairo.

There are also three other regulators on the canal which are seldom used. As the canal is carried on a high level parallel to the Wady Toumilat its infiltrations have practically destroyed all the cultivable land in that valley. Since the English occupation, certain changes have taken place which have rendered the Ismailieh Canal useful for irrigation, and by locks at Zagazig it now connects with the regular canal system of the eastern Delta. By hermetically shutting the head of the Ismailieh Canal during flood, and feeding it near Belbeis by the newly constructed Mennayar Canal, the silt clearances have been reduced from 12,362,000 to 5,298,000 cubic feet per annum, being a saving of about \$40,000. During summer the operation is reversed and the Ismailieh Canal, with its heavy carrying capacity, feeds many others, and probably doubles the irrigating power of that part of the country. In this way silt clearances have been saved in some of the smaller canals. The Suez branch has been provided with a tail in order to utilize about 17,660,000 cubic feet of water per day, which are now lost in the sand, for irrigating about 2,000 acres of land lying west of Suez.

5. *The Tewfikieh system and its connections.*—Besides the Ismailieh Canal there are six others which contribute to the irrigation of the Delta east of the Damietta branch of the Nile. Two of these start from the Nile between Cairo and the barrages, the others at various points on the Damietta branch. Of late years these latter have been assisted by temporary stone dams just below their mouths, built in April or May and partly removed just before the flood. Some of these canals serve for irrigating the high lands at a distance from it; but as these canals change from year to year owing to silting and other reasons there is no use going into particulars about them.

They are mostly deep canals intended for summer irrigation, and each of them has branches leading into the cultivable lands.

Most, if not all of these, will now be fed by the new Tewfikieh Canal which has just been finished. This canal, which is 65 miles long, leaves the Nile at the barrages, where there is a regulator and a lock admitting of the passage of vessels, so that there will be direct water communication through it from Cairo to Damietta and Port Said. The bottom width is about 85 feet at the head, the depth from about 15 feet to 20 feet. The calculated discharge is about 300,000,000 cubic feet per day in low Nile and about 600,000,000 cubic feet during high Nile. As the canal has only just been opened no report has yet been made on its actual working.

The whole superficies of the cultivated land of this part of the Delta is 1,124,305 acres, and according to the received basis to allow irrigation of about 4.35 inches per acre, the canal should give a continual discharge of 4,415 cubic feet a second. Now, according to official accounts in the year 1880, there were only 3,532 cubic feet furnished during low water. In 1881, only 2,861 cubic feet, and in 1882, the year of the Arabi insurrection, only 2,331 cubic feet. This shows how easily an irrigation system goes to the bad unless it be continually kept up.

I may say here in parenthesis that in the year 1873 I had occasion to visit the province of Kuldja, properly Chinese territory, but then temporarily occupied by Russia in consequence of internal troubles, although now retroceded to China. It was curious to observe how land which had been once fertile owing to irrigation gradually became again a bare steppe through the failure of water. In following the line of an ancient water course one could easily trace the transition from cultivated land to desert. One may now see the reverse in the wonderful vegetation about Ismailieh and Suez, where until the Ismailieh Canal was finished the desert had for centuries been waterless. It gives hope that the cultivated land of the Delta may again reach those limits which it had under the Pharaohs and even under the Greeks.

In these eastern provinces of the Delta about 211,920,000 cubic feet of earth have to be moved every year; that is, about 185.81 cubic feet per acre. This has been diminished in recent years. At the same time the annual cost of keeping up the canals and dikes amounted to over \$500,000, or about 77 cents per cultivated acre.

(6) *The Menoufieh system.*—Of the two central provinces of the Delta—the two richest in Egypt—situated between the Damietta and Rosetta branches, that of Menoufieh, lying to the southward, has an area of 340,000 acres, every one of which is cultivated, and its population of nearly 1.9 to the acre is entirely engaged in agriculture. The holdings are small and the cultivation every one states to be superb. The railway from Alexandria to Cairo passes through the center of this province and all the travelers are struck with the way in which the ground is utilized.

The northerly province, that of Garbieh, contains 860,000 acres under cultivation, 600,000 acres more which are cultivable, and 180,000 under water. The main irrigating canal is the Menoufieh, which starts from the point of the Delta between the two barrages. After running 23 miles it is divided into the Bahr Shibin escaping into the Mediterranean west of Damietta, and the Bahr Bajur discharging into Lake Barilos. Two large canals are fed with water by the Rayah, three by the Bahr Barilos, and eleven by the Bahr Shibin, all of which are supplied with regulators and many of them with escapes.

The chief work done by the English engineers in these provinces

since 1884 has been the reduction of silt clearances, chiefly by means of subsidiary canals running in flood only and creating a current, one regulator being closed while another is used. The saving has been very great. The Sahil and Nagar canals, for instance, formerly cost the one \$75,000 annually for corvée labor, giving a summer discharge of only 7,064,000 cubic feet for the twenty-four hours, while the latter cost \$90,000 and discharged only 3,532,000 cubic feet. "Pumping engines," Mr. Willcocks says, "placed at 13 feet $1\frac{1}{2}$ inches higher level would have delivered 88,300,000 cubic feet for the twenty-four hours for the same sum of money."

On these two systems of canals the corvée cleared in 1883 45,244,920 cubic feet, costing \$257,600, while in 1887 the necessary clearance was reduced to only 2,371,960 cubic feet, costing \$10,600. Among other advantages of the reduction of silt clearances are that the rich Nile mud is carried out to the fields at a proper time, instead of being deposited in the canal; that all the canal beds are sufficiently low to take in water for irrigation during winter before the annual clearance, which takes place between February and April; and that these canals are open to navigation during winter at the time when the regulators may all be open.

(7) *The Behera systems.*—The province of Behera, which lies to the west of the Rosetta branch and is very difficult to irrigate, contains 900,000 acres of land, of which less than half, 390,000, are cultivated; 260,000 more might be reclaimed and the remainder is under water.

This province is irrigated by three main canals, all connected, the Behera, which starts above the Rosetta Barrage; the Khatatbeh, which starts 28 miles lower down and joins the Behera; and the Mahmoudieh Canal, which starts from the Rosetta branch near Atfeh, flows into the harbor of Alexandria, and supplies that city with drinking water. Between the barrage and Khatatbeh the desert comes so near the Nile that the Behera Canal has to pass through over 14 miles of pure sand. Here it is very difficult to keep up the canal, not owing to any considerable amount of sand blown from the desert, but owing to the changes of the bottom consequent on the change of the water level. The Egyptian engineers met this difficulty by keeping Behera as a summer canal, shutting its head by an earthen dam in flood, while they used the Khatatbeh as a flood canal; but, although the water-level was constant, the level above the barrage was so low that the discharge was considered insufficient, and the insufficiency led to the erection of a pumping station at Khatatbeh to lift water in summer.

Mr. Willcocks says:

The Mahmoudieh Canal was dug by Mehemet Ali in 1819-20, with the object of opening a direct water way between Cairo and Alexandria, supplying the latter town with water and providing for summer irrigation. This canal was fed in a novel way. An area of 60,000 acres to the south of Atfeh was surrounded by a dike filled with water in flood, and turned into a reservoir for supplying summer water to the Mahmoudieh. In 1849 it was considered cheaper to lift the water from the Nile and cultivate the basin; consequently pumps were erected at Atfeh. * * * At Khatatbeh the water is lifted by five huge centrifugal pumps with vertical shafts, while at Atfeh there are six scoop-wheels.

The discharge at Khatatbeh is 88,300,000 cubic feet per twenty-four hours and at Atfeh about 70,640,000, the lift in the former case being about 8 feet $8\frac{1}{4}$ inches as a maximum and $6\frac{1}{4}$ feet as a mean; the lift at Atfeh is $6\frac{1}{4}$ feet as a maximum and 4 feet as a mean. The pumps at Khatatbeh are well constructed and excellently managed, and yet they are showing signs of deterioration, owing to faulty designing. All the rubbing surfaces of these enormously heavy machines are vertical, which makes it exceedingly difficult to keep them oiled, and this means wear and tear.

If renewals are ever necessary they will be very costly indeed. Their one chance of life lies in the splendid management and unceasing supervision. Machines like

them will never again be erected in Egypt. A number of easily manageable 48-inch and 54-inch Gwynne pumps, with a separate channel for each group of three or four, would have been better. If the original screws at Khatatbeh had had diameters of 7 feet instead of 10 feet, and been constructed on the same principles as the screws at Sherbin, they would have been working to-day.*

The irrigation company have a contract with the Government which lasts till 1921, to lift annually in summer up to 88,300,000 cubic feet per twenty-four hours at Khatatbeh, and 88,300,000 cubic feet per twenty-four hours at Atfeh, for an annual indemnity of \$128,073, and \$204.37 per 35,320,000 cubic feet per twenty-four hours at Khatatbeh, and \$136.25 per 35,320,000 cubic feet per twenty-four hours at Atfeh. In 1888 the company received \$249,382, and pumped 150,110,000 cubic feet per twenty-four hours throughout the summer.

As there has been a chronic deficiency of water in the Behera province during summer and winter, the Government in 1885 and 1886 was tempted to use the Behera Canal in flood. But as the groynes with which it had been provided were insufficient the canal silted up completely and had to be dug out again. In spite of large sums paid for pumping—from \$200,000 to \$250,000—annually, dredging these three canals is always necessary on account of navigation, water supply in winter, and the fear of allowing silt to accumulate. The expense of this system and the fear of being obliged to multiply Khatatbeh pumps throughout Lower Egypt led Sir Colin Scott-Moncrieff to take to working the barrages, and so far this has been a great saving. A very complete project for remodeling the three canals just mentioned has been made and has already begun work. The Government in connection with a private company has also dug a new canal called the Nubarieh in order to reclaim some of the desert land west of the Nile; and another company is endeavoring to reclaim the Aboukir Lake which has evaporated only since 1882.

(8) *The barrages of the Nile.*—These constitute the most imposing irrigation work in Egypt and may prove to be one of the most important. At the beginning of the century Napoleon, who saw everything and who from his life on the Rhone must have understood something about irrigation, spoke of the necessity of damming the Nile at the apex of the Delta, so as to send the whole supply first down one branch and then down the other, and thus double the irrigating power.

In 1833 Mehemet Ali, finding it exceedingly difficult to clear the summer canals to a sufficient depth to receive the low-water supply, began closing the Rosetta branch with a huge stone dam, so as to send all the water down the Damietta branch, from which the chief canals were to be fed. Monsieur Linant, afterwards Linant Pasha, persuaded Mehemet Ali to stop this, and proposed the building of two dams, one on each branch, about 8 miles below the bifurcation. He intended to build them on the dry land, then turn the Nile through them, and stop up the old beds with earthen dams. This plan was approved, and Mehemet Ali even ordered the Pyramids to be taken down and the stones to be transported to the spot. But when the methods of demolition and transport came to be considered, Linant Pasha dissuaded Mehemet Ali from this idea by explaining to him that, as the Pyramids were built from the bottom to the top it would be necessary to begin to demolish them from the top, and that this proceeding will be more costly than quarrying fresh stone. The work had been well begun, the foundations were being excavated, material had been collected and workshops built, when the viceroy suddenly changed his mind, stopped the work, dug the summer canals deeper by the aid of the *corvée*, and nothing more was heard of the barrages for 7 years.

* Very large machines seem not to answer in localities where repairs are difficult and costly, and generally postponed till it is too late.

Bed-
30

BLOCK PLAN
OF
THE BARRAGES

Scale: $\frac{1}{50,000}$.

REFERENCES.

A, B, C, D, E, F, Protective Spurs.

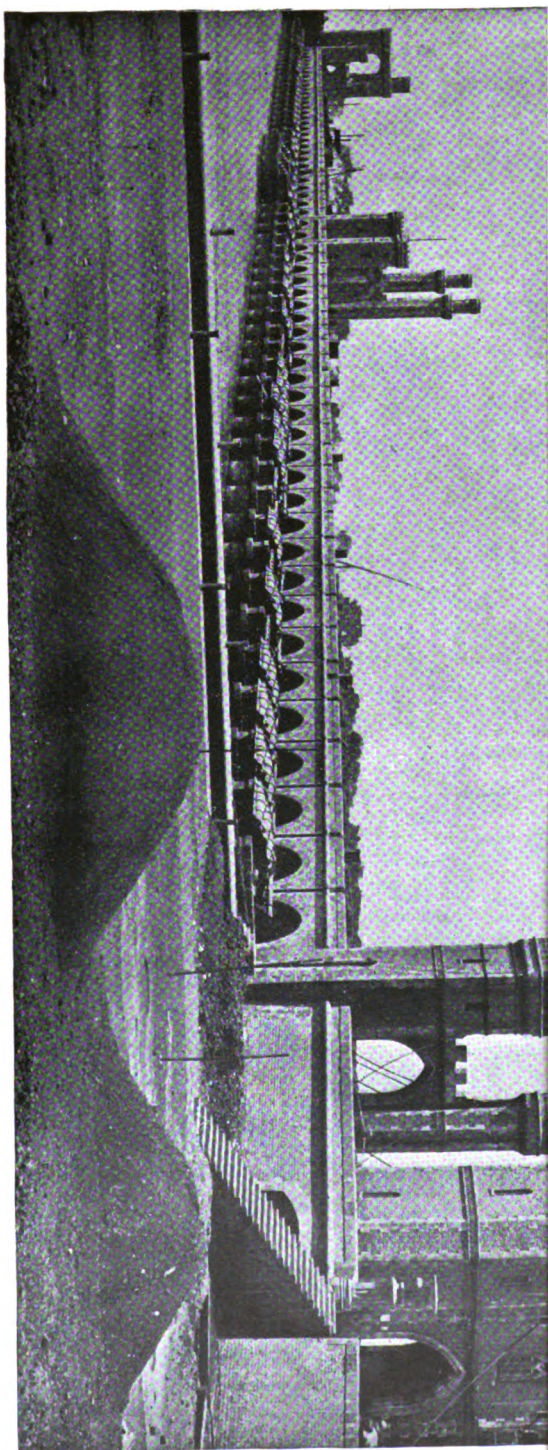
J, K, P, Training Spurs.

G, H, I, L, M, N, O, Training Permea

*Training Works begun in 1884. By .
Sand Bank formed opposite Spurs F, I
and the Sand Shoal X eaten away.
Channel Y increased in size sixfold.*

MAXIMUM FLOOD DISCHARGE

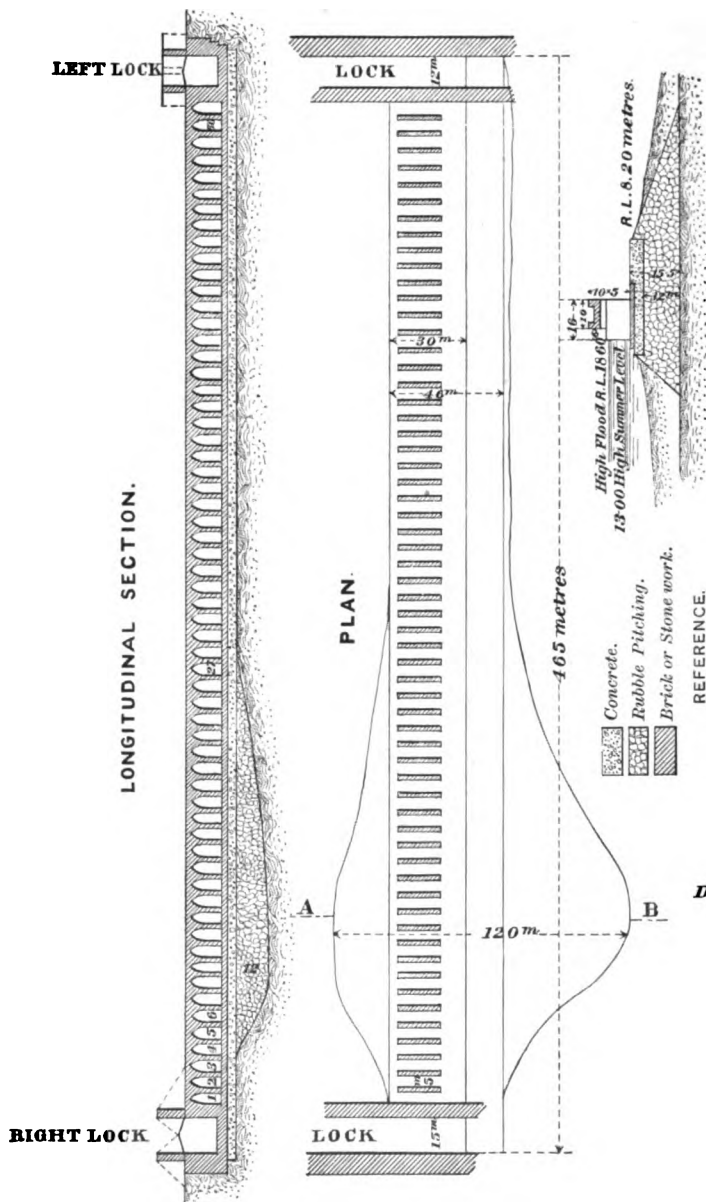
*Main Nile, - - - 1,032,000,000 c'm
Rosetta Branch, 562,000,000
Damietta Branch, 405,000,000*



BARRAGE ON THE NILE.

ROSETTA BRANCH BARRAGE.

JANUARY, 1884.



CROSS SECTION ON A B.

Scale, $\frac{1}{3000}$

In 1842 Mougel Bey came to Egypt and recommended the establishment of the dams on the present system together with a series of fortifications that could defend Cairo. The idea of fortifications pleased Mehemet Ali, who took the idea of making the site of the Barrages the military capital of Egypt. The works were immediately begun, but Mehemet Ali died in 1848, and in 1853, after 10 years, the works of the Barrages were not sufficiently advanced to please Abbas Pasha, so that Mougel Bey was dismissed and a new man ordered to finish the work on his plans. The works were finished in 1861, the cost, exclusive of the *corvée*, being \$9,400,000. Counting the *corvée*, the canal heads, the fortifications, and everything, the barrages are estimated to have cost over \$20,000,000. The barrage of the Rosetta branch was closed for the first time in 1863, and had to be reopened immediately, owing to the settling of part of the work. Some repairs were made and the Rosetta barrage was used to some extent up to 1867, when the bulging of part of the bridgeway caused fears for the safety of the work, and it was entirely abandoned until 1884, when it was taken charge of by English engineers.

The object of this work is to form a reservoir for low water and to give a sufficient head of water to increase the flow through the irrigation canals in the Delta. It consists practically of an open dam over each arm of the river, that over the Rosetta branch being about 1,527 feet long, and that over the Damietta 1,740 feet long, built upon stone and concrete platforms flush with the river bed and therefore about 29 feet above mean sea level, connected by a revetment wall about 3,283 feet in length. Just above the Damietta barrage there has been opened the new Tewfikieh Canal already spoken of, which will feed nearly all the canals on the east of the Damietta branch; midway between the two barrages is the Menoufieh Canal, which will now feed all the canals of the central provinces between the two branches; and to the left or westward of the Rosetta barrage is the opening of the Behera Canal, which is now being remodeled in the hope that it will prove of greater service than hitherto.

In the barrage on the Rosetta branch there are sixty-one arched openings, which during the low Nile are closed by curved iron gates let down by means of crabs traveling upon rails upon the bridge. The barrage on the Damietta branch has ten openings more, or seventy-one in all, which are closed in the same way. The barrages having been pronounced valueless except to regulate the flow of water in the two branches of the Nile, it had been resolved to adopt an extensive system of pumping to supply the water to the cotton crops of the Delta. This pumping was to have cost \$1,440,000 a year.

Not satisfied with this conclusion, Sir Colin Scott Moncrieff resolved to see what he could do with the barrages. Everything was in a bad state, especially the timber and machinery. The barrage on the Damietta branch had never been closed, and the openings had no gates. Attempts were made to remedy these defects, and the arches, first of one and then of the other of the barrages were closed, so that ultimately, in June, 1884, 7 feet 2 inches of water were held up on the Rosetta barrage, and 3 feet 1 inch on the Damietta barrage. Even this small amount conveyed a much larger quantity of water through the Central Menoufieh Canal and delivered it at a higher level, so that many pumps stood idle that year. All this was done at a cost of about \$128,055. In 1885 the barrage bore a head of 9 feet 10 inches, and the canals starting above it had 4 inches greater depth of water than in 1884.

The experiment having thus far proved successful, there came the question of the completion of the work. Mr. Willcocks thought that, while keeping the barrage of the Rosetta branch, it would be cheaper, instead of completing the Damietta barrage, to make a second weir a few miles north of Benha. The site was carefully surveyed and detailed estimates were prepared, but it was found that this project would cost at least \$1,425,000, so that it was given up. A similar suggestion for a new weir across the Rosetta branch, a short distance below the old barrage found favor, but the estimates for this were \$1,620,000. The repairs of the barrage were at that time estimated at \$1,000,000, "coupled," as Colonel Western, the English engineer, remarked, "with doubts as to the possibility of execution."

The repairs which will probably be finished next year will probably amount to \$2,000,000, but with each year the confidence of the engineers in the result of their work has been growing. I have purposely omitted the technical details, and will remark only that one of the difficulties encountered has been the appearance of springs, both in the floor of the barrage and through the apron constructed in front of it. These have been generally cured by the insertion of pipes, and the springs have either been staunched or have been led away so as to be harmless. The springs of the Nile water are the worst, but there has been a curious appearance during the last and the present year of springs of sulphur water of apparently the same kind as the water of the sulphur baths of Helouan, about 15 miles north of Cairo, coming apparently from an underground river which feeds these baths.

The work of repairing the barrage has been more criticised than anything else attempted by the English engineers and yet it has been on the whole their most successful achievement.

Of course the political question comes in. The barrages had been built by Frenchmen and had ultimately been condemned by them; they were therefore unwilling that Englishmen should take it up and even attempt to make it successful. Sir Colin Scott Moncrieff fortunately found Mougel Bey still alive and was able to persuade him to go to the barrages, and to explain his original ideas, his method of construction, and the defects so far as he knew them. The French therefore accused Sir Colin Scott Moncrieff of picking Mougel Bey's brains to his own advantage. But owing to circumstances there had been a rivalry between Mougel Bey and Linant Pasha in which the latter had got the advantage, and Mougel was left poor and almost friendless. In all the time of their supremacy the French engineers had done nothing for him. Sir Colin Scott Moncrieff paid well for the information he received by procuring for Mougel Bey a well-deserved pension.

WORK OF ENGLISH ENGINEERS.

On this subject Mr. Willcocks says:

The works that the Indian engineers have attempted to carry out during their five years' stay in Egypt may be classed as follows:

(1) The strengthening and securing of the barrages so as to insure a constant high-water level during summer, and not only utilize the whole summer supply of the Nile, but do away with a great part of the heavy silt clearances.

(2) The construction of escapes and supplementary flood canals, so as to irrigate during summer from the summer canals, and during high Nile from the summer canals in their lower reaches, and supplementary flood canals in the upper reaches of the summer canals, and thus reduce silt deposits.

(3) Having reduced silt deposits to a manageable amount, to substitute dredging and contract work for the *corvée*.

- (4) The obtaining of flood supplies as early as possible into the flood canals.
- (5) The reduction of regulation of the supplies entering the summer canals during flood so as to save the lowlands from inundation.
- (6) The improvement of the lowlands themselves by drainage and basin irrigation.
- (7) The improvement of the navigation.

In all this they have been eminently successful, though it is true that when they came matters were at such a pass that it was hard to make them worse.

DRAINAGE AND RECLAMATION.

Drainage is in the upper part of the delta natural, and owing to the slope of the ground is disposed of by subsoil flow, but in the lower part, where the canals are at a high level during most of the year, and the valleys not much above sea level, the subsoil springs from the Upper Delta come to the surface and demand artificial drainage cuts. These cuts would be necessary even if there were only dry crops; with large tracts under rice and basin irrigation, the necessity for drainage cuts is imperative. Canals running north and south do little harm to the drainage, as they follow the natural slope of the country, but those running east and west, especially those following the lines of railways, are mere traps for catching drainage, allowing it to stagnate and hurting the land for some distance on both sides.

The natural drainage lines are well marked in Egypt and are generally provided with some kind of cut in the deepest part, which are cleared annually and are becoming fair drainage channels. In clearing a neglected drainage line it is better to complete the lower reaches before the upper part is touched, even at an expense of time, dredging well into the lakes; and in making clearances it is better to throw all the earth on one bank for a certain length and then on the other bank, which prevents the cut from being afterwards treated as a canal.

Mr. Willcocks says:

The introduction of summer irrigation into any tract in Egypt means a total change in crops, irrigation, and indeed everything which can affect the soil. Owing to the absence of rain the land is not washed as it is in other tropical countries, unless it is put under basin irrigation. An acre of land may receive as many as twenty waterings of about $3\frac{1}{4}$ inches in depth each, *i. e.*, a depth of water 5 feet 10 inches per annum, which is allowed to stand over the soil, sink about 18 to 20 inches into the soil, and then be evaporated. Since the Nile water, especially in summer, has salts in excess, these salts accumulate at the surface, and if not eaten down by suitable crops soon appear as a white efflorescence. While the spring level is low capillary attraction can not bring up the salty spring water to the surface, but when the spring level is high the salt water comes to the surface, is there evaporated, and tends to further destroy the soil.

In old times the greater part of the land was under basin irrigation, and was thus thoroughly washed for some 50 days per annum; while the rest, consisting of the light, sandy soils near the Nile banks, was protected by insignificant dikes, which dikes were burst every very high flood, and thus allowed the land to be thoroughly swept over by the Nile, and washed once every seven or eight years. All this is at an end now in the tracts under summer cultivation, and other remedies have to be found. It is a fact generally admitted in Egypt that washings of the land in winter are far more effective than in summer, some say, because the water is clear in winter and capable of dissolving the salts; others say, because the water is cold in winter.

It is possible to reclaim lands which are grown bad either by the cultivation of summer rice or by basin irrigation; but summer rice needs irrigation in May, June, and July, and there is not enough water in summer to reclaim the low lands in the northern part of the Delta. We know that in Ptolemaic and Roman times the whole of the lands were cultivated; but what was then the "choice land" is now wilderness, a mere barren plain with vestiges of canals and dikes, and

mounds strewn with bricks and pottery. The lakes must have been kept at a higher level and must have had more frequent connections with the sea than they have now.

As basin irrigation decreased the discharge passing through the lakes decreased and the openings gradually disappeared. Only one is now left to each lake. Therefore during the inundation the levels of the lakes rise and the brackish water blights all the land it covers. An example of this is the Borillos Lake and the Bahr Saïdi, which during the flood discharges about 706,332,000 cubic feet per day into the lake. Had this natural branch of the Rosetta Nile always existed it would have kept the sea opening to the lake from silting up, but it has been gradually increasing and cutting a deep channel during the whole of this century until stopped in 1886, when the lake in flood rose only 20 instead of 40 inches. Even this could be stopped by clearing the silted opening of the lake before flood.

There is among scientific agriculturists, as well as among the English engineers, in view of the gradual deterioration of the land, a strong opinion in favor of at least a partial return to the old system of basin irrigation in the Delta. This was practiced 40 years ago and may be thus briefly described: The lands were divided into basins of about 1,000 acres each, provided with canals for filling, basins for retaining water, and drains for discharging it. If the drainage cut was near the canal the basins were easily drained into it. If the drainage cutting was too far off, one system of basins, those next to the canal, would drain back into it while a second system was fed by a series of small cross canals and drained into the drainage cut. Mr. Willcocks says:

The introduction of cotton cultivation into the Birrôja on wholesale principles caused the basin system to be abandoned, while the cotton crop and the basins in rotation might have continued together, both to the advantage of the cotton and to the preservation of the land. This, however, was not done. All the fields were planted with cotton, and produced fairly well; gradually the lower fields fell out of cultivation owing to salt efflorescence and lack of drainage. As the higher fields were now called on to produce a double share of an exhaustive crop, while they received no manure or Nile deposit, they had to be planted with cotton and rice alternately, to prevent their complete deterioration. The drainage water of the rice fields was run onto the lower lands and completed their ruin. New canals dug without levels or alignment, and the conversion of all the drainage cuts into irrigation canals, was all that was needed to destroy the higher lands. This soon followed.

In many places now the tops of the old banks and the beds of the old canals are the only places which yield a crop at all. The only remedy for all this is a return to the basin system. The State Domains administration clearly sees this and is trying to reintroduce basin irrigation on a large scale. It seems ridiculous that during the summer months, when the water has no fertilizing property, and there is very little of it, it should be utilized in irrigating a few fields here and there, scattered over all the basins, and that owing to the presence of these crops the whole series of basins should be deprived of the rich muddy fertilizing water of the flood. If the summer crops were confined to a few basins in rotation the rest might be flooded with the muddy water and rendered as fertile as they were when the ruined mounds which fill the horizon were populated towns and villages.

WATER STORAGE.

In order to guard against the consequences of an insufficient Nile flood, as well as for summer irrigation and even for reclaiming land, various plans have been proposed for water storage, the most important of which are the following:

(1) *The Wady Rayan project.*—The Wady Rayan is a depression in the Libyan desert shaped like a clover leaf, discovered by Mr. Cope Whitehouse in 1886, at the southwest of the Fayoum and separated from the cultivable land by a range of low hills about 3½ miles wide and

at least 118 feet above the sea level, except that there are two passes into the Fayoum at the level of 85 feet above the sea. The deepest level of the Rayan is 130 feet below sea level. Mr. Whitehouse was led to his explorations by his previous archaeological studies, which had induced him to believe that the Fayoum was the ancient land of Goshen, and to seek here for Lake Moeris, described by the ancient writers, as well as for the famous Labyrinth. When this depression was found, which is now generally acknowledged to be the site sought for by Mr. Whitehouse, his studies took a practical form, as he thought that this basin might be turned into a storage reservoir of water, to be filled by high Nile, which could be used for irrigation during the dry season.

Mr. Whitehouse has spared neither pains nor money to lay his project before the public, and, apart from his being an American, it is well worth studying.

Mr. Whitehouse was given many facilities by the Government officials, and surveys were made of the locality, which, though not perfect, are sufficient to indicate the important nature of the place and its future possibilities.

The great question is the cost of the original outlay and so far the Egyptian Government, while apparently believing that it is a plan which must be acted on at some future date, finds that in the present condition of things there is not sufficient money in the Treasury or the prospect of it to undertake the work for some years to come.

According to Mr. Willcocks and other authorities on irrigation in Egypt this depression could be filled up to a contour of 88 feet above the sea by the end of the third year after the canal was finished; in the fourth year it would be in full working order and could be filled up to 92 feet. According to this calculation this reservoir would have an area of between 153,000 and 157,000 acres and would hold between 635,760,000,000 and 671,080,000,000 cubic feet of water. So far as is known at present it would be necessary to take a somewhat roundabout route for this canal from Bibbek on the Nile to the reservoir, about 29 miles; the direct road in a straight line, about 19 miles, not having been as yet surveyed.

During the time when the reservoir was in use it could give a discharge of over 423,840,000 cubic feet per day, for which the existing canals would be sufficient, but the lands to be reclaimed near the sea would have to be provided with canals and drains, and this would cost at least \$10 per acre.

The estimated cost of the work is \$7,945,000, if everything is done thoroughly. The canal would take 3 years to complete if machinery is freely employed, and the reservoir would take 3 years to fill.

Prime cost.....	\$7, 945, 000
Interest at 5 per cent. for 6 years	2, 383, 500
Total cost, including interest.....	10, 328, 500

By carefully selecting the site of the canal and economizing in the hill slopes, the price might be reduced to \$9,000,000. The annual interest charge would be, at 5 per cent., \$450,000. The water supply would be 423,840,000 cubic feet per day throughout the summer. This supply would be capable of irrigating 300,000 acres flush in the north of the Delta.

The Government being unable to spend the necessary amount of money at the present time for this purpose, Mr. Whitehouse has proposed to provide a stock company for working it. The Government has refused, being unwilling to allow the general irrigation works to be in-

terfered with by private companies. It will be seen later what a comparatively small amount of money, considering the work to be done, can be expended by the irrigation department, hampered as it is by the limitations of the laws and the jealousies of foreign powers.

With regard to this project Mr. Willcocks says :

The undertaking is so vast, and the difficulty of insuring a return so great, that no private company except a guaranteed one could undertake it. As far as Egypt is concerned, however, the completion of this reservoir would permit of a new province being formed in the north of Egypt, and give an impetus to the reclamation of the waste land which would in the end have a marked effect on the revenues of the country. A company which received the concession of the Rayan reservoir and 400,000 acres of land in the Birriya would need a capital of \$13,500,000. If the undertaking were successful a net profit of 15 per cent. might be obtained, but the company would always be at the mercy of the Government.

(2) *The Kom Ombos scheme.*—Another project of a similar sort is that proposed by Count de la Motte for making a reservoir in the plane of Kom Ombos. For this, however, it would be necessary to build a dam across the Nile at Gebel Silsileh, 53 miles below Assuan. Colonel Ross, assisted by several other engineers, has studied this project during the last winter and finds it entirely impracticable. Apart from the enormous cost, and the fact that the depression at Kom Ombos is much less than has been supposed, it would be extremely dangerous to dam the Nile at that point. One extreme flood would carry away the dam and practically destroy the whole of Egypt.

LAND TENURE.

In Egypt irrigation is intimately connected with the question of land tenure. Private property in land existed in the earliest times. The hieroglyphic records give us no account of it; but if we may judge from the Bible we must suppose that there was individual property in land, and from a political point of view we must admire the skillful way in which Joseph, during the time of the famines, got possession of the land of the whole of Egypt for the Government (Genesis, chap. 41, verses 53 to 57; and chap. 47, verses 13 to 26). The régime established by Joseph by which the whole land became the actual property of the rulers, while the subjects enjoyed only the right of tillage, has lasted from that date to this.

When the Arabs conquered the country they found this system existing and accepted it.

According to Arab law at that time, land was divided into two classes: (1) *Ushuri* or *tithe lands*, which paid as tax a tenth part of the harvest, which were lands fertilized and irrigated by a river of Arabia (which included a great part of Mesopotamia) or lands watered by rain, that being a gift of God and therefore Arabian; (2) *kharadji* or *tributary* lands, which were watered neither by rain nor by an Arabian river, and on which a tax could be imposed at the will of the conqueror. When Egypt was conquered the question arose whether (1) to divide the lands among the conquerors, (2) to leave them to the inhabitants as tributary lands, or (3) to dispossess all the inhabitants and colonize the country with Mussulmans, although in this case the land would still be *kharadji* or tributary.

The Arabs, being moved partly by military and partly by fiscal reasons, decided to accept the second solution, and made the greater part of the lands *kharadji*, leaving the taxes as they had been fixed by the previous Byzantine rulers. Only the few lands which were then confiscated as belonging to special owners, those reclaimed from the desert,

and those which were subsequently confiscated, became *ushuri* or tithe lands. But in all cases it was admitted that the real proprietor of all the lands was the State, as represented by the *khalif* or ruler, whatever his title may have been. The possession of *mulk*, that is, freehold lands, has been of very recent date, nearly all in the present century. According to Mussulman law tithe lands could never be made tributary lands, but the reverse may happen at the will of the ruler.

The result naturally came about, that if lands were left for a certain number of years uncultivated, either through their abandonment by their proprietors, or through failure of irrigation, they reverted to the State and could be granted out again.

In spite of the unknowable antiquity of irrigation of Egypt, there were until very recent time no laws with regard to its management or to the repartition of water among the lands. As the property of the land really belongs to the state and the management of the irrigation system belongs to the state, the tillers of lands had only the natural redress, that if their lands could not be cultivated they were exempt from taxes. This, of course, followed naturally on the *ushuri* or tithe lands, where the tax was properly a harvest tax, and it was gradually admitted on the *kharadji* or tributary lands, where the tax was properly a land tax.

According to the existing laws remission of revenue is granted on land incapable of being sown with the winter crops although flood crops irrigated by lift are expected to pay the full taxes, but no provision is made for crops destroyed by floods during the inundations, or by drought in summer. There is great need of a definite law on the subject, because owing to the fact that there is plenty of water when the crops are sown, they are often sown to excess, and as the summer supply of the Nile only suffices for about one-third of the area in lower Egypt in May and June there are very often failures of harvest. All such cases are now decided by the native court and the mixed tribunals on the basis of certain articles in their codes, but these are very insufficient. Mr. Willcocks says:

Owing to the costliness of the tribunals, and the unlimited power of appeal, a poor man who has his watercourse obliterated by his rich neighbor, has nothing to do but to submit to the best terms he can obtain, *i. e.*, either sell his land for half its value or buy his water in future. Many estates are nicely rounded off in this way in Egypt. It is not only the poor who suffer while this undefined state of affairs exists; the state itself is helpless. It is a common opinion in the country that the government can never win a case in the tribunals. If a spur is thrown up one bank of the Nile to protect an engine, the other bank prosecutes the government; if the engine is not protected the owner of the engine prosecutes. If the Nile is low and a canal runs dry from natural causes the government is prosecuted. If a canal is too full, owing to a lack of regulators, the government is prosecuted. And this not in a country where the government sells the water, but where the government performs functions that the atmosphere does in other countries. However, things have become so bad now that something must be done. Previous to 1882 the *mudirs* or civil governors protected the poor as a rule from Jews and Christians, while the state was strong enough to hold its own. Now the tribunals dominate the state, and are unable to help the poor.

EXPENDITURE.

Irrigation in Egypt is under the charge of the ministry of public works. While the minister is an Egyptian, the under secretary as well as the inspector-general of irrigation are Englishmen, and the most important parts of the service since the English occupation have been confided to English engineers, most of whom have seen service in India, though some foreigners as well as natives still continue to hold inferior posts in the service.

The estimates of the budget for 1890 give for the expenses of the central administration \$160,970, and of the technical administration \$84,935. By no means all of this is properly to be set down to irrigation expenses. The total budget for 1890 of the public works department is \$2,209,550.

The first circle of irrigation includes the provinces of Galoubieh, Sharkieh, and Dakablieh. The salaries and general expenses are put down at \$74,740; new works, \$90,750; keeping up and in repairs, \$51,340; making a total of \$216,830.

In the second circle of irrigation, which includes the provinces of Menoufieh and Garbieh, the salaries and general expenses are put down at \$50,005; new works, \$20,850; keeping up and in repairs, \$107,525; making a total of \$178,380.

In the third circle of irrigation, including the provinces of Behera and Ghizeh, the salaries and general expenses are put down at \$60,680; new works, \$73,500; keeping up and in repairs, \$65,500; for furnishing water, \$250,000; making a total of \$449,680.

In the fourth circle of irrigation, including the provinces of Benisouef, Minieh, Assiout, and Girgheh, the salaries and general expenses are put down at \$69,240; new works, \$109,125; keeping up and in repairs, \$75,125; making a total of \$253,490.

In the fifth circle of irrigation, including the provinces of Keneh and the frontier, the salaries and general expenses are put down at \$28,680; keeping up and in repairs, \$15,000; making a total of \$43,680.

The expenses for the Fayoum are put down at \$37,100, and those for the works on the barrage at \$55,285. This would make a total of \$1,234,445 apart from the central and technical administrations, not all of which strictly belong to the irrigation service.

The work of dredging the canals, as well as of maintaining the dikes on the banks of the canals, was formerly done by the system of forced labor; the whole male population being nominally liable to this service. Owing to the efforts of Sir Colin Scott Moncrieff, the *corvée* system was gradually suppressed and finally put an end to by the Khedivial decree dated December 19, 1889.

Nevertheless, while the *corvée* has been abolished in the ordinary sense of that term, the forced labor of the population still continues for the general supervision of the bank of the Nile during a high flood. This, however, is a question of supervision rather than of forced labor, for all the rural population feels that the maintenance of the dikes during high floods is not a question of property on the part of proprietors, but one of life and death for themselves and their families.

A grant of \$1,250,000 yearly was made for the partial suppression of the *corvée*, and this should be included in the irrigation budget, as well as the sum of \$75,000 a year to be raised by taxation for the total suppression of the *corvée*. The total ordinary expenses of the irrigation in Egypt should therefore be put down for the present year at about \$2,560,000.

There are, however, also extraordinary expenses. In 1885 a decree allowed \$5,000,000 to be spent for the improvement of the irrigation works. Of this there had been spent on December 31, 1888, the sum of \$4,233,075. There will be allotted from a new loan now being negotiated the further sum of \$4,550,000 for the same purpose.

EUGENE SCHUYLER,
Consul-General.

UNITED STATES CONSULATE-GENERAL,
Cairo, June 11, 1890.

REGULATING THE NILE FLOOD.

REPORT BY CONSUL-GENERAL SCHUYLER, OF CAIRO.

The rise of the Nile during the present year has been what is called *very good*, measuring at Assouan $17\frac{1}{4}$ pics, and thus supplying a sufficient quantity of water for irrigating the whole country. About a foot more would have overflowed the dikes and would have probably carried away many of them, producing great damage and devastation. As it was, measures were so promptly taken that very little loss has occurred through the destruction of dikes and walls; what breaches were made were promptly repaired.

The consequences to this year's agriculture of the low Nile of 1883 were not so disastrous as were at first anticipated.

After the low Nile of 1877 an acre of 947,471 area remained uncultivated, causing a loss of revenue of \$5,559,400. About 300,000 acres of land were not covered by the water of 1888, making the loss of revenue about \$1,730,000.

This called the attention of the Government to seek some remedy for the future. Lieutenant-Colonel Ross, inspector-general of irrigation, has prepared a scheme, which, when properly carried out, will prevent in Upper Egypt the disastrous effects of a low Nile, and will keep many thousand acres in good cultivation.

To keep up the fertility of the lands in Upper Egypt, two things are necessary: (1) the overflow of the red, muddy water on the land; (2) the retention there of the water for a certain length of time.

On the lands under basin or submersion irrigation in this country no account need be taken of manure, plowing, etc. But as the millet crop (*Holcus sorghum*), or sorgho, gives from 66 to $82\frac{1}{2}$ bushels of grain per acre, and as one man can water a quarter of an acre from a roughly made well, and thus after the labor of four months have 1,000 pounds of grain on hand, the temptation to raise sorgho is very great. The sorgho crop very rapidly exhausts the land unless the red water remains on it for at least twenty days in the year. The red water is best during August; owing to the sorgho crop, it is seldom laid on the land before the middle of August.

There are three distinct pulsations in the rise of the Nile, called flushes, the first of which occurs in the last week of August, and with this the best red water is furnished. It is, therefore, desirable that the lands be covered with water during this period. The flush marked at Assouan on August 24, 1888, was recorded at Cairo on August 30, showing that the velocity was $97\frac{1}{2}$ miles per day.

The second flush is during the first twelve days of September, and then the regulators are generally closed in order to force the water on the high lands; the water, however, is not so good as that of August; it is to the eye distinctly less chocolate colored and is said to contain only 36 per cent. of the organic and alluvial matter in suspension brought down in August.

The last flush is in the last ten days of September after the river has waned, and its level is considerably less than that of the other two, which are about the same.

SYSTEM OF IRRIGATION.

The system of irrigation pursued in Upper Egypt is that known as the basin or submersion system, by which water can be allowed to stand,

and, in fact, must stand, on the land for a determined period of time, as distinguished from the canal system, where the water is brought upon the land by ditches at the will of the cultivator. Two factors govern the formation of the basins:

- (1) The slope of the Nile Valley as well as of the Nile bed.
- (2) The gradual slope from the Nile banks to the desert, for, owing to the alluvium brought down, the Nile bed gradually rises.

WATER DISTRIBUTION.

The present system of distribution consists of directly irrigating canals distributing small quantities of water throughout their course at a very low level, combined with canals running in the hillside hollow which have in some cases been passed on to the next system, but which in many cases flow into the end basin and cause it to rise slowly. Their middle and upper reaches are not irrigated till September and then only by the damming of regulators.

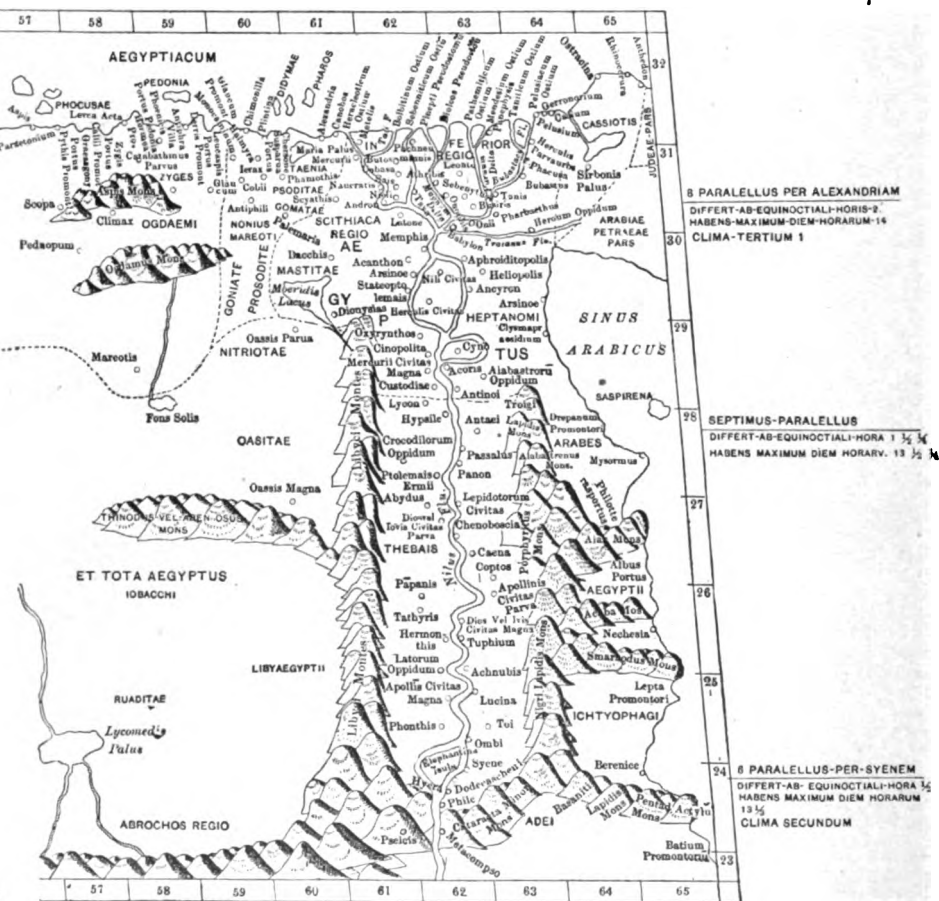
The first basin is therefore generally full before the water begins to run into the second, and so on, and there is always a temptation on the part of cultivators to dam the water in the canals and use it for irrigating purposes before the basins are full, and the result is large silt deposits.

The new system, suggested by Lieutenant-Colonel Ross and adopted by the Government, is not to allow the water to traverse the basins longitudinally except where there is a special canal for the low lands. It is proposed to institute a series of high level canals which will not begin to distribute water into the basins until the Nile has reached a certain altitude, and will thus be able to irrigate the whole country even at times of low Nile. By this system the necessity of silt clearance will be much reduced. But besides digging canals it is necessary to regulate the exit of water so as to prevent damage during high Nile, and for this purpose much masonry work will be required.

It was estimated last year that in order to carry out this system within 5 years it would be necessary to spend \$4,250,000. The financial administration, being hard pressed for money, has found this sum too great, forgetting that it is only an investment, which in the course of a few years will be repaid by the increase of land tax collected and the ease with which it can be done. The sum actually spent during this year has been about \$135,000. There will be allowed for 1890 about \$625,000, a sum which is considered too small by the department of public works, which demands at least \$1,250,000 for the works of the coming winter.

EUGENE SCHUYLER,
Consul-General.

UNITED STATES CONSULATE GENERAL,
Cairo, December 4, 1889.



ANCIENT EGYPT

Drawn from the map in the Ptolemy of 1508.

EGYPTIAN SUPPLEMENT.

THE RAIYAN MOERIS.*

BY COPE WHITEHOUSE.

[NOTE.—This paper, republished by permission, contains the substance of an address made before this society on November 11, 1889. It was illustrated by lantern slides which gave the complete cartography of Middle Egypt, including hieroglyphic, Greek, Arabic and modern maps; as well as by original views of the Bahr Jusuif, the Fayoum, Raiyan and Muallah depressions, and the adjacent desert.]

The journal of this society (vol. xiv) contains, under the title of Lake Moeris, the results of those early explorations in the Fayoum and the adjacent desert which have now assumed a transcendent importance. The claim there made for the great inland sea has been fully justified. The vindication of the integrity and intelligence of the ancient historians is complete. The splendid engineering works of remote antiquity dazzle the eye and stimulate the imagination of statesmen and engineers, who study the arid plains of the Western States or watch the turbulent floods of the Father of Waters.

Diodorus, the Sicilian geographer, thus describes what he saw during his visit to that part of Egypt: "A little south of Memphis a canal was cut for a lake, brought down in length from the city 40 miles. Its usefulness was worthy of all admiration and the magnitude of the work incredible. The circuit of the lake is said to be 450 miles, and in many places it is 300 feet in depth. Who is he, therefore," he exclaims, "that considers the greatness of this undertaking and does not feel impelled to ask: 'How many thousands of workmen were employed, and how many years were spent in completing it?' Yet, considering the benefit and advantage brought to Egypt by this great work, none ever could sufficiently extol it according to what the truth of the thing deserves. For inasmuch as the Nile never kept to a certain and constant height in its inundation, and the fruitfulness of the country depended upon its uniform and regular supply, this lake was formed to receive such water as was superfluous, that it might neither immoderately overflow the land, and so cause marshes and stagnant ponds, nor, by flowing too little, prejudice the crops for lack of water. Accordingly the king dug a canal from the Nile to the basin, 10 miles in length, and 300 feet in breadth. Into this the water was allowed to run at stated times, and at other times it was diverted and turned over the cultivated land for seasonable periods, by means of sluices which were opened or closed, not without great labor and cost. This lake continues to the benefit of the Egyptians for these purposes to our own time, and is called the Lake of Myris or Meris to this day."

The chief facts given by Diodorus had been anticipated by Herodotus and were confirmed by Strabo and Pliny. It was thus that the attack upon the credibility of Herodotus in reality involved the whole ancient world. Readers and purchasers of books must be held responsible for the demand which creates the supply. Cæsar and Cicero, as well as Plato and Aristotle, would share in the condemnation, although actual mention of Moeris found no place in their works.

The plain account had been flatly contradicted. It was supposed that the observer "embraced in his measurement the whole water system of the Fayoum," or had "confused units of measure," or "the direction of the canal with that of the lake." The accounts of Herodotus (B. C. 454), Diodorus (B. C. 20), Strabo (B. C. 24), Pliny (A. D. 50-70), were declared to be "widely different" and "irreconcilable." Finally the scientific world came to the unanimous conclusion that Moeris was "an artificial reservoir, 45 miles round, 25 feet deep at high Nile, and drained at low Nile when the waters had been used upon the fields of the Fayoum. It was everywhere stated that the position of the lake had been satisfactorily determined, in this sense, by M. Linant de Bellefonds. The map reproduced from the "Egypt" of Canon Rawlinson (1881) shows the accepted view.

The French Government had also printed upon its map (1882) that the memoir of M. Linant contained all the information which could be desired. The name of Rawlinson, identified with widespread geographical knowledge, a thorough acquaintance with Herodotus, and the current researches recorded by the Royal Geographical Society, is sufficient to show that no suspicion of error on Linant's part was then entertained.

It is not necessary or expedient to trace here the successive steps which have resulted in our possession of an immense body of accurate observations made by a series of experts. Cartography, geology, history, and archaeology are represented by men of high rank, while from the premier of Egypt to the prime minister of Great

* From the bulletin of the American Geographical Society, No. 4, December 31, 1889.



Map of the Fayoum, showing the Birket-el-Keroun and the artificial Lake Mœris (from Rawlinson's Egypt, 1831)

Britain, documents have been issued showing that the suggestions, embodied in little more than a pregnant phrase, are deemed to have a bearing upon the welfare of Egypt, the future of Africa, and the imperial interests of more than one great power. "Beside Lake Moeris," said Herodotus, "lies the Labyrinth. I visited this place and found it to surpass description." Beside the Fayoum and Raiyân basins in their physical conditions as developed by the engineer lies an edifice which has some of the romantic elements of the palace of Aladdin. The lamp which traces its walls reflects a thousand figures weird, and yet with many a familiar feature. In its twelve halls are throned twelve patriarchs. The history of one, at least, who dwelt on the banks of the Nile, is a household tale on the slopes of the Himalayas and the prairies of the West. Into these sinuous passages and recondite researches we may not now enter. The Rabbi Benjamin, of Tndela, points to this "land of the West" (Pi-Tum), and says: "Here is Pithom. Here are the remains of the buildings erected by our forefathers." Jablonski could write, but dared not publish that the Fayoum was the land of Goshen, vainly sought by the modern scholar in the pestilential marshes of Menzaleh, or the scant strip traversed by the Ismailich Canal. The only questions we are authorized to discuss are those purely geographical points which were outlined by the president of this society in the remarks in which he summarized the issues raised in the former paper on Lake Moeris. He assumed that the geographical features set forth with such detail and minuteness were accurate and trustworthy. Further evidence on this point will be duly marshaled and original authorities cited. An examination had been made of all the cartographical evidence from the time of Claudius Ptolemy. The facsimile of the map of Egypt from the edition printed in Rome in 1508, and similar to several of those manuscripts which abound in the Vatican and other European libraries, can now be compared with an official map, stamped with the approval of the International Jury at the Paris Exposition.

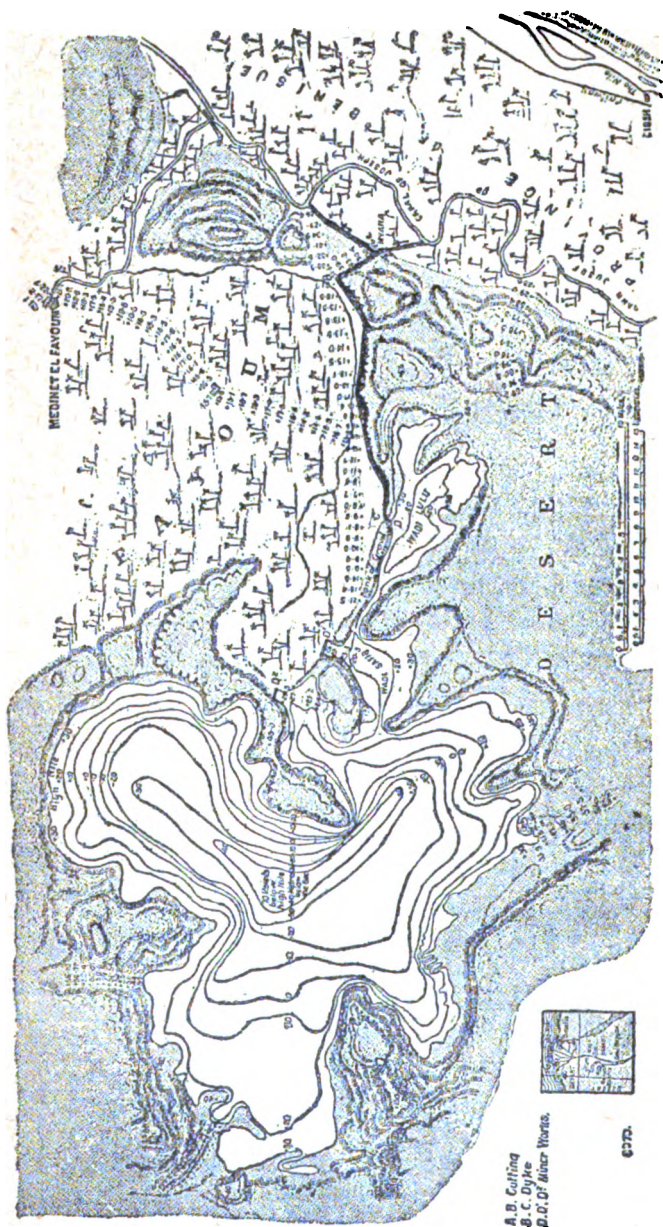
The undoubted existence of comprehensive and stupendous works, still used for their original purpose after the lapse of 4,000 years, shows what estimate should be formed of the capacity of the rulers of Egypt to design and its inhabitants to accomplish. It has an important bearing upon current philosophy and the strangely rash and incoherent assertions of rate of progress and development.

The wish of your president has been fulfilled. The condition of things in Egypt has brought about a survey of this neglected region, not merely with a view to gratify curiosity in respect of its past condition, but to point out the means of guarding against calamitous results from the action of the Nile. These investigations are apparently on the eve of being turned to practical account, and a part of the surplus of the inundation diverted into the Wadi Raiyân. The lesson has already been taken to heart in the New World. The Mississippi and the Rio Grande will yet be treated as the Nile. The engineers who trace back their technical education in geometry to the engineering schools in the University of Memphis are scanning with interest the tradition that makes the patriarch Joseph the founder of their profession, and studying with profit the mighty works that were done of old and still endure.

Curiosity has, unfortunately, also been directed to the archaeological treasures of this region. Savage attacks have been made upon its monuments, and thousands of tombs rifled with hideous disregard of decency. It tempts one to deplore that so much had to be said, and to guard with jealousy the secrets still undisclosed. It is for the members of this society to use their moral influence to secure to Egypt the undisturbed possession of the treasures accumulated in the past, as well as to aid its industrious peasants to obtain such further benefits from the Nile as will put the Government once more in a position to devote its surplus earnings to the advancement of art and science within its borders, and extend humanizing influences through Central Africa.

The accompanying map—reduced from the large map 1:50,000—prepared in the department of public works in Cairo, succeeds and replaces several smaller maps, resulting from the surveys made by me or by engineers put at my disposal by the Egyptian authorities.

Colonel Ardagh, C. B., R. E., then chief of staff to the British army of occupation, but now holding the high and responsible position of secretary to the viceroy of India, was the first English officer to visit the Wadi Raiyân. At the meeting of the British Association in 1887, before the London Chamber of Commerce in 1888, and in the proceedings of the Royal Geographical Society in 1889, he has enforced the importance of the Raiyân depression. It was largely due to his support that the irrigation department consented to further an official examination of this area. The scientific world owes him this addition to the large debt which it acknowledges for his topographical labors elsewhere, and his map of the neighborhood of Tel el Kebir. Captain Surtees, for several years on the staff of the Egyptian army, whose military services had been fully appreciated, after his return from the mission to Central Arabia, on which I accompanied him, was detailed in 1887 to examine the Fayoum in the strategic aspect which had been outlined to Gen. Sir Evelyn Wood, and to join me in an expedition to settle the western limits of the two depressions.



The Balyan Basin, drawn by Cope Whitehouse, 1888.

The results are recorded in official documents in the foreign office, and in the proceedings and on the map of the Royal Geographical Society for that year.

The Paris Geographical Society had early recognized the probable value of these investigations. In 1886 it preferred a request for an address, which, in compliance with their wish, was made without notes, but a summary was published in their bulletin.

The Exposition Universelle offered an opportunity of exhibiting a number of maps, surveys, and official documents. These satisfied the experts, who represented the various countries of the world, that the generous confidence so liberally extended to a stranger had materially helped to protect and mature the ideas which had, in fact, first found shelter in the pages of the *Revue Archéologique*. This collection of maps included a portion of a hieroglyphic map, whose central part is preserved at Būlaq. The remainder was found in a country house near Lincoln, England, and the fact announced in a volume offered by Egyptologists to Dr. Leemans. At the Congress of Orientalists in Vienna Dr. Pleyte, of Leyden, who was the first to embody the Raiyān basin in any map published on the Continent of Europe, brought to my notice a papyrus in the possession of Dr. Reinisch. It was readily identified as the fragment stolen from the museum at Būlaq, of extreme interest in cartography, and whose probable destruction had long been lamented.

Various reports on the Raiyān Basin by Sir C. C. Scott-Moncrieff have less value than would have been anticipated from the world-wide reputation of the author of Irrigation in Southern Europe. It naturally seemed to him scarcely within the bounds of ordinary human events that, in a brief interview, one whom he had never seen before, who was to leave Egypt the next morning, should draw a few lines on a scrap of paper, add and subtract a few figures, and offer to the future under secretary of state for public works, without any condition or apparent expectation of reward, an unrivaled occasion for enhancing personal reputation, saving a distressed people, and reconciling in one great enterprise the conflicting interests of France and Great Britain. Whether those lines were worth hundreds of millions of dollars is still a matter of calculation. The estimates made by Sir C. C. Scott-Moncrieff, which at Sir Evelyn Baring's suggestion he published in the *Journal Officiel* a year since, were confessedly—intended to minimize the dissatisfaction expressed at the delay in the actual execution of the project. They showed a net profit of 10 per cent. on the estimated cost, but must be considered as the work of the statesman, not of the engineer. He treated the death rate of Cairo—92.7 per 1,000 in July—as a *quantité négligeable*, and the obligation to furnish water to the Suez Canal Company, as well as to the peasants of the Gizeh Province, for which they have long been annually taxed, as the payment of a debt, and therefore not a source of additional revenue. The quit-tance of these and similar obligations was excluded in the estimate of profit to be obtained from the execution of the scheme.

Lieutenant-Colonel Western, C. M. G., R. E., director-general of works, was charged in 1887 with an examination of the whole project. His great ability and thorough knowledge of construction have been proved, notably at the barrage, but also in many minor works. If his estimates of cost seemed large, and even the enormous area of 3,000,000 of acres, to be added to Egypt by the creation of the Raiyān Reservoir capable of increase, his invaluable reports are not to be criticised. His personal examination of the region and further facts have combined to modify, to some extent, his conclusions in a more favorable sense. These reports constitute the basis on which everything has since proceeded. They were the complete official acquittal of those who had preferred the statements of Herodotus and the maps of Cl. Ptolemy to those of Dr. Lepsius and the modern cartographers.

Lieutenant-Colonel Ross, as inspector-general of irrigation, has, like Sir C. C. Scott-Moncrieff, been in a measure hampered by his official position in the expression of opinion. His map of the Fayoum and Raiyān depressions is constantly receiving new items of great interest, especially in that northern part where a large area of cultivable land was found by me, and brought to the notice of the British and Egyptian Governments at a time when the refugees from the Soudan were demanding aid to establish new homes. To Colonel Ross was due the diagram of the rise and fall of the Nile for 14 years, which was a prominent feature in the exhibit in Paris; as well as countless suggestions and continuous moral support.

The relief-map of the Raiyān Basin—horizontal scale 1:100,000; vertical scale 1:10,000—made by M. Muret under my supervision, aided by photographs, was so striking in its contrasts that it completely broke up, in the minds of all who studied it, the fatal error, so universally entertained, that the desert traversed by the Nile is a sandy plain. The difference of scales is unusually great, and therefore far less deceptive than those maps in flat relief, which seem to the inexperienced eye to give a natural appearance to the mountains and valleys.

There was also submitted for the examination of geographical experts a large map of the Northeastern Delta, with the areas actually productive or capable of being rendered cultivable by an additional supply of water free from alluvial deposit.

This map was due to Mr. Garstin, who, as inspector of irrigation for the Eastern Delta, is well acquainted with the region.

Major Brown, R. E., is in charge of the provinces of Middle Egypt, traversed by the Bahr Jūsuf or river of Joseph. Why should oriental scholars have overlooked those written traditions, which, dating back from the ninth century to the period when the book of Genesis first embraced the forty-ninth chapter, have always assigned this work to the Hebrew premier, whose sagacity founded the temporal fortunes of his race? The claim put forward in behalf of Saladin—chivalrous opponent of Cœur de Lion—comes nearly two centuries after Masudi, in A. D. 956, had described the island and habitation of Joseph, the province of *Ben Jusuf*, as it is suggestively termed on Mercator's map, and the Beni-Suef of our own day. Several beautiful photographs, taken by Major Brown with artistic taste and technical skill, illustrated the lecture delivered before this society and the expeditions we made, in which we followed this great stream. Like the reputed author of its existence, it bears a name to show that separated from the parent Nile, it takes away the reproach of barrenness from a large district and adds yet another province to the area assigned by Semitic tradition, ancient and local, to the shepherd kings and their allies, the Beni-Israel.

Mr. Marshall Hewat is inspector and director of works in the Fayoum. The photographs showing the palace of the Mūdīr were proofs of the hospitality so often enjoyed, and of the information obtained directly from him as well as from the governors, my old friend Murad Pasha, and the present governor, an accomplished and learned professor, Latif Bey Salem.

Nubar Pasha had at various times urged upon his highness, the Khedive, and his immediate associates in the government of Egypt, the necessity of providing an additional supply of "*sefi*," or "low Nile" water, himself prepared with a project for a great dam at Silsilah. The danger of creating a storage reservoir by a dam across a large stream is well known. The engineer seeks, by preference, to use some supplemental stream, issuing from a lateral valley.

The Silsilah project has of late been associated with the name of Mr. de la Motte. It was, however, so obvious a means of accomplishing a desired object that it had been mooted since the expedition of Bonaparte, and its advantages and serious dangers carefully weighed by successive ministers, especially by Ali Pasha Mubarekh when minister of public works. The Khedive opposed it, with characteristic soundness of judgment. He has recently been termed by the late consul-general of the United States a model prince. His sons will soon visit the United States, and this society will, without doubt, take that occasion to express their appreciation of this ruler of Egypt, who is the devoted husband of one wife, an affectionate father, profoundly religious, wisely administering his private affairs, and discharging his duties as Viceroy, under circumstances of extreme difficulty, with a tact and zeal which have won the respect of all who know him, and the loyalty of his people.

In the *Zeitschrift der Gesellschaft für Erdkunde* (Berlin, 1886, No. 2), Dr. Schweinfurth has given an account of his expeditions through the Muellah, Raiyān, and Fayoum depressions, with a map. It is in the form of a letter to Dr. Ascherson and contains much valuable geological information. It will be remembered that it was stated in the journal of this society that I had received information of the existence of a temple in the desert to the north of the Birket el Qerūn. Its position was indicated to the north of the ruins described by Dr. Lepsius, Dimeh. The engineer, however, whom I had taken with me to Dimeh, insisted upon my agreement to return him to Medinet before a given date. Dr. Schweinfurth found the building without difficulty, and enjoys the credit of having been the first European to visit and describe it. Accompanied by Lieutenant-Commander Ackley, U. S. N., I visited and photographed it in March, 1889. It is a rectangular building, about 70 feet in length, 25 in depth, and 18 in height. The photographs were examined by MM. Chipiez, Maspero, and Naville. They consider the structure, in all probability, of extreme antiquity, *circa* B. C. 2000. Its geographical importance is very great. Situated 5 miles from the shore of the present lake, at the level of high Nile at El Lahun, and at the foot of the steep terraces which bound the depression to the west, it must have been constructed when the Fayoum was a vast lake. It would then have been a point of military importance on the desert road from the south to the Natron lakes or (the ancient) Alexandria.

Dimeh is also detached; so that it would appear as an island rising with steep sides out of the lake, where it was deepest. If Diodorus states that he saw such an island, crowned with two pyramids, against which were colossal seated figures, and a tomb, where the water was 300 feet in depth, and if in the Fayoum there is a detached hill, with a long, horizontal street or quay, covered with immense masses of unburned brick and stone, which, when the Fayoum served as a back-water and flood-escape for the Nile, may have corresponded to this description, is it creditable to insist any longer that the statements of the Sicilian geographer and traveler are false? Herodotus before, and Pliny afterwards, refer to the same remarkable feature. The pyramids of El Lahun and Hawara, at either end of the Fayoum Canal, are of unburned

brick. The island pyramids may have been of the same material. In any event the stones at Biahnu ought never again to appear in any argument as in any way identified with these pyramids or with the statues as *in situ*. It is an elementary rule of evidence, which is constantly ignored by untrained minds, that you can not discredit your own witness. The only knowledge of these structures is derived from the written statements of Herodotus, Diodorus, and Pliny. The whole story may be rejected, but it is puerile to admit their existence and then to identify pyramids and statues with extant remains on the upper terrace of the cultivated land, when the only important fact was the indication which the island furnished of the great depth of the "excavated" or "eroded" depression.

The contours of the Fayoum have not yet been completed. It was urgently impressed upon Sir C. C. Scott-Moncrieff, in 1886, that lines should be run which would determine the entire area of the alluvial deposit of the Nile, from Assuan to the Mediterranean. It might have been done without appreciable cost to the Egyptian Government had my offers been accepted. Unless, however, an engineer had been lent to me who would be responsible to the Government for any error, neglect, or disobedience of orders, the public works department would not have accepted the work as final. Some such survey will, it is believed, be undertaken at no distant date.

The contour of high Nile, quitting the Nile Valley at el-Lahun, passes to the south of Gharag, enters the Wadi Raiyān, encircles the Wadis Lulu and Safir, reenters the Wadi Raiyān, crosses the entrances of the Oases of Muallah and Khoreif, and returns into the Fayoum after girdling an area of 250 square miles. This same contour, of R. L. +30, would continue round the west of Gharag towards the north and east, and then passing westward to the south of Qasr Qerūn, turn to the north, and, sweeping out into the desert behind Dimeh to the ancient temple, curve towards the east, and return to the south and the valley of the Nile along the foot of the hills which overlook the ancient bed of the Bahr Wardan.

It may be said that this line when it had reached el-Lahun and the cultivated land in the province of Beni-Suef, would, especially if the minor sinuosities were measured, attain a length of 450 miles. The entire basin, thus encircled, would apparently cover over 1,300 square miles, and a large part of it would be much below the level of the Mediterranean.

This was the immense natural back-water of the Nile, which, according to Semitic tradition, was divided between the fertile province to the north, when el-Hūn or Phiom (the Sea) became el-Fayoum (Alf-ium, the land of a thousand days), and the Raiyān Moeris, or reservoir to the south.

If the Arab tradition is correct, King Raiyān invested Joseph with the insignia of prime minister as a reward for about 400,000 acres of land, perennially irrigated. Manetho says that this region was abandoned in the religious wars which broke out at the time elsewhere fixed as the birth of Moses. The Birket el-Qerūn rose, if not then, subsequently. The Lake of the Horns submerged once more the district of Qerūn (Hersonopolis) to the upper plateau, where repeated use of the word Sen points to Ha-Sen (Gesen, Goshen), Asenath, the wife of Joseph, and Arsinoe, its Ptolemaic name. Those united depressions formed the Moeris of Herodotus.

The region might well be described, in the fifth century before our era, as a vast reservoir and back-water from the Nile, with a maximum level above low Nile at Memphis, 50 miles southwest of that city, about 50 fathoms deep, longer than its width, extending from north to south, surrounded by the Libyan desert, with an indented coast as long as the smooth sand banks which form the Mediterranean shore of Egypt, blue, full of fish of twenty-two species, with flood gates at the double mouth of the canal, whose embankments and clearance from silt annually cost \$50,000 (£10,000), by which the engineers relieved Egypt from a dangerous flood, or stored up and distributed the water which entered or issued from the canal. A multitude of fishermen on its borders were engaged in catching and curing the fish which bred and multiplied in the lake, while the royalty on the fisheries averaged \$250,000 (£50,000). Its waters escaped along the hill above Memphis. About the middle of the deepest part was an island. On it were two pyramids and a tomb. Against the structures were two figures, seated upon thrones. The height of the pyramids equaled the maximum depth of the lake.

The *Lacus Meridis* of the Ptolemaic maps—the Raiyān Moeris—is confined to the Raiyān depression, with an extension into the narrow valley of Muallah. The term Raiyān retains the name of the monarch honored by Islam, associated locally with the spring in the southernmost bay of the depression, and closely connected by derivation with the idea of irrigation. Moeris, of course, is, like the Latin word *mare*, or the English "mere," the exact equivalent of lake.

THE RAIYĀN PROJECT.

The whole subject of Egyptian irrigation has been treated with conspicuous thoroughness and ability by Mr. W. Willcocks, of the Indian public works depart-

ment, and one of the four inspectors of irrigation, who, under Col. Sir C. C. Scott-Moncrieff, under secretary of state for public works, and Lieutenant-Colonel Ross, inspector-general of irrigation, succeed the Hyksos, Persian, Greek, and French in foreign control of the native engineers. His book embodies the information collected during 44 years of the irrigation systems of Egypt, and a résumé of the works carried out by Sir C. C. Scott-Moncrieff. The literature of irrigation, in general, is singularly scanty. Scarcely a dozen titles can be found in the catalogue of any library. The volumes published by the State of California will soon be supplemented by those to be issued from the State Department in Washington. Mr. Willcocks provides a treatise which discusses systems of irrigation practiced with eminent success for 4,000 years. It is curious to read how steel may now be introduced with advantage in the sluice-gates of canals for which the Sphinx was sculptured as warder.

One of its eleven chapters, one-twelfth of the entire contents of the book, is devoted to the Raiyân project. The whole volume is replete with information and will be found to be of the greatest value for all who are engaged in land reclamation schemes in countries where the rainfall is insignificant. Extensive citations from this book have an obvious advantage. They are free from suspicion of exaggeration. They present prolonged and recondite researches reduced to logical sequence and coherent form by a practical engineer, who contemplates that he may himself be intrusted with the execution of the works he recommends, and required to earn the interest which he promises on the capital which he estimates as sufficient. Mr. Willcocks appears to urge that summer irrigation impoverishes the land, and that basin irrigation, or an annual crop from flooded land is, in the long run, more productive. He has, however, explained that he objects to perennial irrigation when unaccompanied by those periodical floodings, in which the rich red waters of the Nile deposit the detritus of the Abyssinian mountains, mingled with the decaying vegetable matter transported by the White Nile from the swamps and marshes of Equatorial Africa.

Colonel Ross, in his admirable preface (p. xv), shows the difficulty of draining middle Egypt, especially the tract alongside of the Ibrahimiyah Canal, or, in other words, by the side of the railway between Beni-Suef and Assiut. The Nile flood absolutely bars drainage into the Nile; the Raiyân basin offers the ultimate solution of this problem. In future years, he says, after the Wadi Raiyân Canal has been opened, and the summer supply of the Delta assured, the money now spent in raising water to irrigate can be spent in draining the extensive northern swamps; the irrigation water being delivered free-flow.

It is simply incredible that strenuous efforts are continually made under the direction of the great powers, who represent civilized Europe, to destroy the navigation of the Nile. Artificial obstacles are placed across the canals, and all the mouths of the Nile barricaded as soon as a low stage of the water is reached. The financiers, protected by British bayonets, force transportation out of its natural channels onto the railways, or delay it for 24 hours at a bridge, for the more convenient collection of tolls, whose character has been stated with entire frankness in the official utterances of Sir H. Drummond Wolff and Sir J. Fergusson. The benefits of the Raiyân scheme include improved internal water communication.

Colonel Ross gives an analysis of the chapter which treats of "the recently developed project of the Wadi Raiyân." "The storage of water in this sister depression to the Fayoum will remove many difficulties about summer supply. The principal difficulty is to get the capital, either by borrowing, or forming a company to furnish the water in exchange for some concessions. Considering that it now costs £60,000 (\$300,000) to pump 5,000,000 cubic meters (say 1,250 million gallons) of water into the Behera province, it does not seem a bad bargain to borrow a million and three-quarters (\$8,750,000) to furnish 20,000,000 cubic metres of water daily (capacity 8,000 cubic feet per second) and even more, i. e., to pay £87,500 (\$437,500) a year at 5 per cent. interest." As Colonel Ross points out, Egypt could borrow the necessary funds at 5 per cent. In other words the Raiyân project is considered by him an absolutely safe investment.

Two propositions were submitted to the British officials in Egypt:

First, having placed unreservedly at their disposal all the information I had acquired, and having submitted to the fantastic, and, in my judgment, cruel and extortionate demands upon my life, health, and private resources in doing their work, in months spent in the desert with their engineers, or in putting my knowledge in a form in which it would influence the scientific, political, and financial world and smooth their path, I offered to efface myself and leave them untrammelled in the execution of the work and the appropriation of the merit.

No remuneration of any kind, direct or indirect, was to be given me. It was to be considered sufficient if I were allowed to escape scot-free without the *paine forte et dure*, which, in Goethe's opinion and my own experience, are still ready to invest with picturesque accidents the most judicious efforts to ameliorate the human lot or add to its intellectual wealth.

Second. When it was insisted that the gift to Egypt was incomplete unless the

canal itself was finished without risk or cost to the bondholders or the taxpayers, and a net surplus paid into the Egyptian treasury, it seemed again that this was no function of mine, or necessary part of my work. The scientific examination of the Moeris problem required but a single visit to the untrodden summit of the Haram Medhuret el-Berhi, while any engineer could be invited and paid to spend 30 days in running lines of level through the Haret el-Gehenna, whose name is well deserved. So also the great powers have furnished their ward with a financial staff, whose experience ranges from St. Petersburg to Calcutta. It was no business of mine to obtain the opinion of Lord Rothschild, the council of foreign bondholders, the Imperial Ottoman Bank, or Sir J. Lubbock.

Two offers were nevertheless submitted. The first left to that bureau in the department of works specially created and charged with the expenditure of a million of pounds, guaranteed by the great powers, all the engineering work. My confidence and that of the Egyptian Government in the skill and energy of Colonel Western and his staff was so complete that there was little difficulty in obtaining authority from capitalists to provide the Government with funds as the work advanced, secured upon the works themselves with such participation in the benefits as might be determined. A scale was suggested.

The second offer simply accepted the estimates of the Egyptian Government and contracted to complete the work on their terms. We would agree to deliver the Raiyān Canal and flood-gates, according to specifications, for an annual payment not exceeding £50,000 (\$250,000), purchasable for a lump sum of £1,000,000 (\$5,000,000). The annual rent was in no case to exceed 70 per cent. of the net profits obtained by the Government. These offers have not so much been rejected as their final consideration postponed. They have been repeated and defined in the "Note on the Raiyān Project," submitted to the department of public works in April, 1899. There is very little doubt, however, that the Egyptian Government, having expended another year in striving to find some other way of accomplishing the result, will borrow the money, guaranty the interest, and itself do the work.

Considering its importance and the acknowledged benefits which will be immediately conferred upon Egypt, and through the valley of the Nile on the equatorial provinces, which have been transferred to the Mahdists, since the British occupation, as the result of the military and civil operations conducted by Hicks, Gordon, Wolseley, and Stanley, advised by Sir E. Baring, no personal interest should be allowed to intervene. What, in comparison with such results, is the naked assertion of the abstract right to bring to maturity a project, although the inception is admittedly the offspring of one's brain and heart, whose infancy required sedulous care, and the infant, destined to be Hercules, was cradled in a shield and defended by the sword?

There are four possible channels by which the Raiyān Basin can be put in communication with the river. Two only are considered by Mr. Willcocks. The Abu-Hamed route involves a contoured canal in the desert along the southern edge of the Fayoum. It was regarded by Colonel Western as in all respects feasible at a moderate cost. Whether a shorter line through the limestone hill would, on the whole, be preferable is not for the moment essential. The former line fixes a maximum cost which can be used in working out the other elements of the project.

The only alternative scheme for the impounding of the surplus flood is that associated with the name of M. de la Motte. He proposes to build a dam across the Nile at Gebel Silsileh, 85 kilometers (50 miles) below Assūan (the first cataract) and make a reservoir in the desert plain of Kom Umbos. "This scheme is in a very embryonic stage and needs very much more working up to bring it to the complete and perfect state of the Wady Raiyān project, but it is roughly calculated to cost £4,000,000 (\$20,000,000)" (p. 322). Its great weakness lies in the dam 60 feet high, founded on a not very homogeneous sandstone. Other objections include the detention and deposit of silt, with the consequent raising of the bed of the reservoir and annual diminution of its capacity.

The summary of the Raiyān project, as given by Mr. Willcocks, is substantially in the following words; the parentheses are mine:

The cultivated area of Egypt is 4,955,000 acres, and the land capable of reclamation in Lower Egypt (exclusive of over 1,000,000 acres contained in the areas now abandoned to the Mediterranean and forming the brackish lakes bordering upon it, together with at least 500,000 acres elsewhere) is 1,260,000. If one-third of the cultivated land and the whole of the land to be reclaimed were to be irrigated in summer, there would be required a summer supply of

$$\left(\frac{4955000}{3} \times 26\right) + (1260000 \times 40) = 93,000,000$$

cubic metres per day, of which the lands to be reclaimed would alone require 50,000,000 cubic metres per day. The mean summer discharge of the Nile is 42,000,000 cubic metres per day (16,800 cubic feet per second) at Assūan, while there are years

when it falls to 24,000,000 cubic metres per day, and hence the impossibility of doing any reclamation by summer cultivation on a large scale without storing water somewhere. The best known scheme before the public is that of Mr. Cope Whitehouse for storing water in a reservoir to the southwest of the Fayoum. This reservoir would be fed by a canal from the Nile in flood and discharge back into the Nile in summer. The time during which the reservoir would be drawn upon would be from the 15th of April to the 25th of July, when the Nile is at its lowest. The elements of the problem, therefore, are the following:

First. A basin of sufficient magnitude to receive the Nile in flood; and of sufficient area to yield between the flood surface of the intake and the low-water mark of the outflow all the additional water required during the hundred days of insufficient Nile.

Second. A canal capable of passing a certain quantity of water into the basin. If the section of this canal is only large enough to discharge the daily supply required from the basin (when filled and used as a reservoir), it will take a considerable number of years to raise the water surface in the depression to the level of low Nile, as the bottom of the depression is over 200 feet below the level of cultivated land in the Nile Valley on the same parallel. If the canal is of large section, it would fill the reservoir in 3 years, and could be used as an escape in time of dangerous flood.

Third. The determination of the water-surface levels of the Nile, maximum, minimum, and mean, during flood and summer, with the discharges corresponding to the different levels.

Fourth. The determination of the minimum level of the Nile in flood, below which it must not be allowed to fall. In other words, the quantity of water which could be delivered at the Raiyān Escape without prejudice to existing interests.

Fifth. The Raiyān works to the west of the Nile Valley, excavations, earthworks, pitching, and masonry works needed for regulation.

Sixth. The works in the Nile Valley needed for the passage of existing canals, drains, and the railway, by the large flood canal or escape.

Seventh. The time required to fill the reservoir; the quantity of water utilized after loss by evaporation and absorption has been eliminated.

Eighth. The quality of the water stored.

Ninth. The effect of reservoir water on the Nile water in summer in respect to the health of the towns depending for their water supply on the Nile.

Tenth. The passage of the water from the reservoir in summer through the existing canals in Lower Egypt, on the top of the ordinary summer supply, in order to reach the lands near the sea.

Eleventh. The preparation of the lands to be reclaimed so that the water may be utilized when it is obtainable.

Twelfth. The cost, capital required, and means of earning interest on the capital.

"Granting the great advantages to be reaped from an increase to the summer irrigation of Egypt, and the necessity of this increase if the resources of the country are to be fully developed, there is no scheme more likely to attain this end than Mr. Cope Whitehouse's project for a reservoir in the Wadi Raiyān, southwest of the Fayoum. At no other place in Egypt can a reservoir be obtained without first building a dam across the Nile." Plate 2 gives a plan of the reservoir and the adjacent valley of the Nile, reproduced from Mr. Willcocks' work, without any modifications; which, nevertheless, especially in nomenclature, might have advantageously been made. "This plan was reduced from the (latest) original plan, prepared by a staff of engineers working under the orders of Colonel Western, director-general of works. The ministry of public works is examining the project in a very thorough manner; Colonel Ross, inspector-general of irrigation, examining the irrigation side of the question, and Colonel Western the constructive."

"Given the reservoir, the section of the canal, the water level in the Nile, and the other factors in the problem, it is a question of permutations and combinations as to which is the best method of carrying out the project. A small canal will cost little; but it will take many years to fill the lake, the interest charges will run up, and the water of the lake will possibly (?) become brackish. A large canal will cost much; but it will soon fill the lake, the interest charges will not mount up, and the water of the lake will possibly not be brackish. A large canal will also be of use in reducing appreciably the water level of the Nile during a very high flood. A very high flood comes seldom, but a breach of the Nile banks in flood is the greatest calamity which can overtake the country; and any scheme which promises relief to the country in flood deserves careful consideration."

With these preliminary remarks Mr. Willcocks proceeds to consider the twelve elements of the problem, as he conceives it, in detail. The parentheses here also contain explanatory remarks by the author of this paper.

(1) *The size of the reservoir.* This is a fixed quantity. In Colonel Western's office, the large scale plan has been contoured and the areas covered by the different con-

tours have been measured by a planimeter. The following table (abridged) contains this information :

Area and cubic contents of the Raiyān reservoir.

Reduced level of contour.	Area in square metres.	Area in Egyptian acres.	Contents of reservoir in cubic metres, below the contour.
30	686,600,000	163,475	20,559,640,000
25	618,300,000	147,214	17,297,390,000
20	550,000,000	130,952	14,376,640,000
10	397,904,000	94,739	9,637,120,000
Sea level.....	301,100,000	71,690	6,142,100,000
10	231,800,000	55,190	3,477,600,000
20	163,075,000	38,127	1,503,225,000
30	55,562,500	13,229	410,037,500
40	22,037,500	5,247	22,037,500

The maximum flood level of the Nile at the (proposed) take-off of the reservoir canal is reduced level +31.8 meters (about 100 feet above the Mediterranean), the ordinary high flood level is reduced level +30.3, the low flood level is 29.0 metres, and the summer level is about 22.0 metres above mean sea. The levels are referred to the Barrage zero, or mean Red Sea, .60 metre above mean Mediterranean Sea.

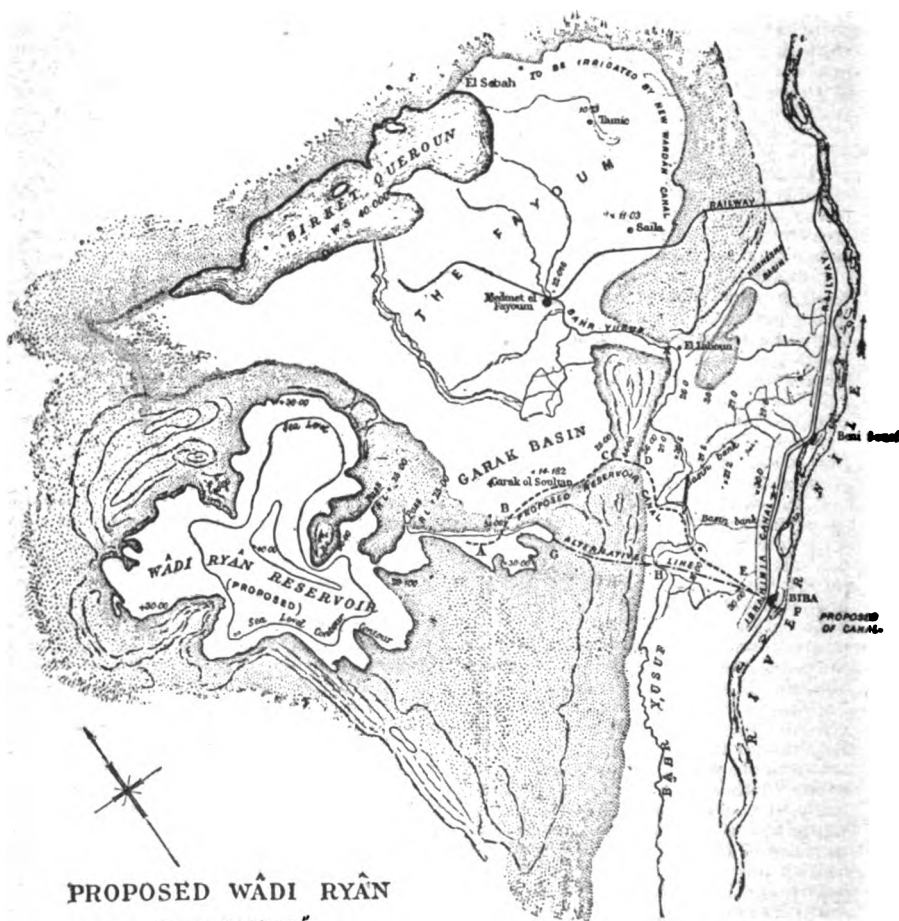
Colonel Western thus describes the Wadi Raiyān : " This valley, a depression in the Libyan Desert, discovered by Mr. Cope Whitehouse in 1886 (this date being taken as the first official communication to the department of works of a survey verified by lines of levels, as distinguished from aneroid observations), lies immediately to the southwest of the Fayoum province, but separated from it by a range of low hills, averaging some 6 kilometres ($3\frac{1}{2}$ miles) in width, and with heights of about 60 metres (196 feet) above sea level. Two passes, however, leading from the Garak (the Rharq of Schweinfurth, the Gharq of the author's maps) basin of the Fayoum, with levels of about +26 metres, have been found in this dividing range, and, except for these two passes or entrances, the Wady is everywhere bounded by hills of at least +36 metres above mean sea.

" The soil of the Wady is for the most part composed of desert sand and pebbles, overlying in places a yellow clay, but this desert sand is for about one-sixth of the area hidden by drifted sand-hills, or ridges rising some 5 to 10 metres above the general plain. Towards the north of the Wady there are two fresh-water springs (but no inhabitants) and near there a few date trees and some brushwood grow. The deepest level of the Wady Raiyān reaches 40 metres below sea-level (about 220 feet below high Nile). To the south of the Wady and connected with it at a level of +55 metres is the Wady Muallah, a valley about $1\frac{1}{2}$ kilometres width and 7 length. Its lowest depression is +25 metres (about 35 feet below mean high Nile near Behnesa, opposite its southern extremity). In the Wady Muallah there are ruins of ancient buildings (with fragments of a Græco-Roman period, further identifying the spot as the Dionysias of the Ptolemaic text and map). There is a fair amount of coarse vegetation near them.

" Two other small depressions have been found connected with the Wady Raiyān at its northeastern extremity at a contour lower than the level of the flood Nile. They lie to the south of the Gharq basin of the Fayoum province and are separated from it by a ridge with a level of +35 metres, 1 kilometre in width. The easterly depression (the Wadi Lulu, or Valley of the Pearl, a modern name given to it by the author of this paper) is about 10 kilometres in length by 4 kilometres mean width and has a bottom at about +15 metres."

(2) *The reservoir canal.*—" Referring to the plan," says Mr. Willcocks, " it will be seen that Biba is the point chosen for the take-off of the canal from the Nile. It is 163 kilometres above the Barrage along the deep channel of the Nile (85 miles south of Cairo by rail). Of course, any other point near it may be chosen, but considering the lie of the basins and their feeders it will be difficult to choose a better place. On the plan there are two lines given for the canal; one is called the ' Proposed Reservoir Canal ' and has been (repeatedly) leveled and surveyed (examined by Colonel Western in person, and pits sunk to test the character of the material to be excavated). The other is called the ' Alternative line.' All calculations have been made on the former. If the surveyors can find a fairly good line along the latter, it will be decidedly the better line, as it makes straight for the reservoir and avoids the banking up in the Fayoum Valley necessary on the former line."

Neither line presents the smallest engineering difficulty, or would be above the capacity of a native provincial chief engineer. The direct line involves a tunnel about 5 miles in length through horizontal limestone. With a bed width of 80 metres and



PROPOSED WÂDI RYÂN
RESERVOIR.

From *Egyptian Irrigation*, by W. Willcocks, 1889.

a height of 10 metres, it would be more convenient to drift a series of openings. Undoubtedly this would be the channel selected if the irrigation department was directed as in the days of Raiyān ibn el-Walid, the Hyksos monarch, who, according to Semitic tradition, proposed to Jūsuf ibn-Jacoub the problem of regulating the Nile, or when Ipsambul and the Sphinx were carved in the living rock, and the hills opposite Memphis emptied of incalculable masses of stone.

The splendid effect of the façade with the stream, 250 feet in width, gushing clear and blue from the white portal, between colossi carved with the least expenditure of labor, but the most ingenious adaptation of natural conditions in the stratified rock, would not now have the slightest weight with the department of public works and their financial masters. The passage itself, its forest of columns, the cathedral-mosque of Cordova extending miles in length, the vast air-shafts, 200 feet in height, corbelled out in moldings decorated with sentences from the Qurán, telling in words that history of Jūsuf written in water, fruits, flowers, fields and houses, temples and mosques along the river of Joseph and in "the land of a thousand days" will not be attempted. Such considerations are absolutely alien to the actual administration as controlled by foreign influences.

It would be otherwise if the viceroy, whose devotion to art and science has been tangibly exhibited, were free to apply the surplus of enlarged revenues according to his better judgment.

"The (total) length of the proposed canal is 46 kilometres (27 miles) from Biba to the point A in the reservoir. The length of the alternative line is about 30 kilometres (18 miles). The slope of the canal will be one twenty-thousandth the ordinary canal slope in Egypt. This slope, with a hydraulic mean depth of between 6 and 7 metres (20 feet) will give a mean velocity of about 1 metre per second (2½ miles an hour), a velocity which allows neither silt deposit nor scour in the Nile Valley."

(3) *Flood and summer levels of the Nile at Biba.*—As a rule there is such a heavy demand for water during the month of August, that in any but a very exceptional year no water (in Mr. Willcocks' opinion) can be taken from the river, and this month must be left out of the calculations.

Discharge of the Nile at Cairo.

Month.	Mean discharge in cubic metres per 24 hours.	Feet per second.	Month.	Mean discharge in cubic metres per 24 hours.	Feet per second.
January	151,000,000	60,400	July	70,000,000	28,000
February	110,000,000	44,000	August	525,000,000	210,000
March	70,000,000	28,000	September	675,000,000	270,000
April	45,000,000	18,000	October	675,000,000	270,000
May	34,000,000	13,600	November	400,000,000	160,000
June	34,000,000	13,600	December	260,000,000	104,000

The maximum flood of 1874 discharged 1,032 million cubic metres in a single day; the minimum flood of 1877 discharged 465 million cubic metres, or less than one-half that amount.

Mr. Willcocks put the entire discharge of the Nile during the year at 93,000,000,000 cubic metres. If 3,000,000,000 cubic metres are required for the basins of Upper Egypt and 50,000,000 cubic metres were furnished for daily consumption, there could never be a year in which 50,000,000,000 cubic metres, or double the contents of the Raiyān Reservoir, would not pass into the Mediterranean without contributing in the least degree to the fertility of Egypt. The regulation of the Nile at the Barrage in July and part of August would put a certain volume of water at the disposal of the government for the Raiyān basin. The summer, or low Nile, level at Biba may be taken as 22 metres.

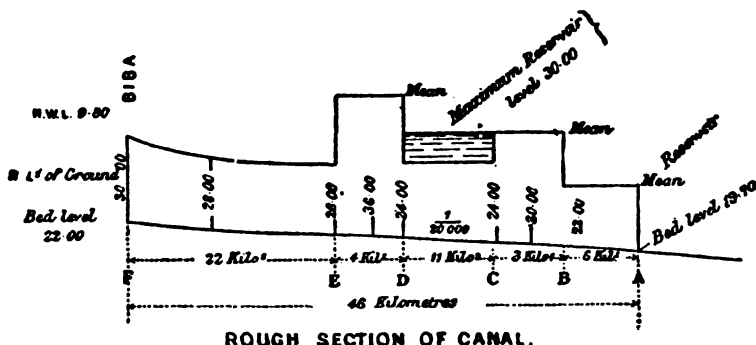
(4) *Levels at which the Nile must be maintained for flood irrigation.*—In September a gauge of 16.3 metres should be generally maintained at the Barrage, though alternate week gauges of 16.3 metres and 15.8 metres (above zero) would suffice for the irrigation until the 10th October. From the 10th to the 20th October a gauge of 17 metres is needed at the Barrage to allow all the highlands to be irrigated for the winter crop. After the 20th October the canal might take as much as it liked from the Nile, or from the basins above it, except in extraordinarily low years like 1888.

In an average year, from the 1st of September there is available a discharge of 57,500,000 cubic metres per day, increasing to over 100,000,000 on the 15th September. Between the 10th and 20th October no supply is available, as the Nile berms have to be irrigated, while after the 20th October the canal can take as much as it can carry. It is better (in Mr. Willcocks's opinion) to depend on an alternate week supply in low

years than on any regulation at the Barrage, because the former meets the requirements of Upper Egypt, north of the canal, as well as those of Lower Egypt, while the latter meets the requirements of Lower Egypt alone. A fluctuating supply in the Nile in a high year like 1887 would bring down the Nile banks, but in high years this alternate weekly supply will not be necessary. In the low Nile years, when it is necessary, no harm will be done by a difference of half a metre, which this system of filling will entail.

As far as a high Nile flood is concerned a canal incapable of carrying 100,000,000 cubic metres per day at the high-flood gauges would be of little use. A difference of 50 centimetres at the Barrage gauge when the readings are between 18 and 19 metres means a daily discharge of that amount. Taking high-flood relief as the most important factor in the calculation (of the size of the proposed canal) and the level of the bed of the canal at 22 metres at the take-off, the canal should discharge 100,000,000 cubic metres per day with a depth of water of 9.8 metres. A canal with a bed width of 80 metres (260 feet) and side slopes of $\frac{1}{2}$ will accomplish this result.

The following is a rough longitudinal section of the proposed canal.



LONGITUDINAL SECTION OF CANAL.

The earthwork estimate is as follows:

From F to E.—Length, 22,000 metres; mean depth, 6.5 metres. Contents, 12,370,000 cubic metres. This is capable of reduction by following the Bahr Jausf in places.

E to D.—Length, 4,000 metres; mean depth, 15 metres. This section is a soft limestone cutting (to the depth of about a metre, resting upon a very compact clay, impregnated with salt, and dissolving with extreme facility into fine mud), and here the bed may be lowered 4 metres, as recommended by Colonel Western, and the depth of water becomes 13.3 metres. The bed width here may be reduced to 40 metres, which will give such a slight afflux that it will not be felt within 10 kilometres of the head. The material to be removed is 4,484,000 cubic metres.

D to C.—Length, 11 kilometres. The hill (along the southern edge of the Gharaq basin of the Fayoum slopes gently from +69 metres to +14 metres) and the canal can follow any contour decided upon (and the required section thus obtained either by a deeper excavation or a higher bank on the lower side—the only one required—as may be considered expedient and economical). If a contour of +24 metres is chosen (and the bank given a top width of 15 metres) a sectional area for the embankment of 200 square metres will cover all contingencies. The breadth of section (varying with the irregular edge of the desert, and reaching in some places a width of 1,500 metres, or over a mile) will make up for any loss in depth; material to be handled, 2,200,000 cubic metres.

C to B.—Length, 3 kilometres, depth, 14 metres, and (bed) width, 40 metres, since this is in part another soft limestone ridge (with pebbles, desert sand, and clay); material, 2,352,000 cubic metres.

B to A.—Length, 6,000 metres; depth, 3 metres; 1,500,000 cubic metres.

The estimated cost of work is:

Section F to E—12,370,000 cubic metres, at £.04 (20c.)	.....	£494,800=(\$2,474,000)
Section E to D—4,484,000 cubic metres, at .10 (50c.)	.....	448,400= (2,242,000)
Section D to C—2,200,000 cubic metres, at .04 (20c.)	.....	88,000= (440,000)
Section C to B—2,352,000 cubic metres, at .10 (50c.)	.....	235,200= (1,176,000)
Section B to A—1,500,000 cubic metres, at .04 (20c.)	.....	60,000= (300,000)

Total.....22,906,000 cubic metres, at .58 (29c.) 1,326,400= (6,632,000)

Fifth and sixth. *Masonry works*.—The masonry works are needed for regulation and for the accommodation of existing works.

1. The Bahr Jūsuf Crossing and Reservoir Regulator. This can be built on the limestone rock with a 40-metre-wide platform and a 2.5 metre depth of masonry; the levels of the canals will allow of a level crossing.

40 openings, at £1,500.....	£60,000=	\$300,000
Wing-walls	10,000=	50,000
2,000 square metres regulating gates, at £9	18,000=	90,000

Total	88,000=	440,000
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2. The Sugar Railway will be diverted to the government railway bridge, at a cost of £20,000 (\$100,000).

3. The Ibrahimia Canal will be siphoned under the reservoir canal. The discharge to be passed is 3,000,000 cubic metres per day, and allowing a head and velocity of 2 metres per second, 8 pipes of 1.5 metres diameter will take the water across.

Estimate 8 pipes at £3,000=£24,000 (\$120,000), 300 tons + masonry.

4. The government railway, 4 feet 8½-inch gauge, 80 metres wide canal. Tons of iron, 1,500, at £25; £37,000 (\$185,000). With the work can be combined the regulating head of the reservoir canal, eighteen openings of 5 metres at £2,500 (\$12,500)=£45,000 (\$225,000).

Railway bridge	£37,500=	\$187,000
Regulator	45,000=	225,000

Total	82,500=	412,500
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The masonry works therefore will amount to—

Bahr Jūsuf crossing and regulator	£88,000=	\$440,000
Sugar railway diversion	20,000=	100,000
Ibrahimieh Canal syphon	24,000=	120,000
Head regulator and railway bridge	82,500=	412,500

Total	214,500=	1,072,590
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The whole of the earthwork and masonry works will therefore (according to Mr. Willcocks) amount to—

Earthwork	£1,326,500=	\$6,632,500
Masonry	214,500=	1,072,500
Land, 1,600 acres, at £30 (\$150)	48,000=	240,000

Total	1,589,000=	7,945,000
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It will be a matter of interest to all those concerned in irrigation works to study these estimates, but no American engineer would, for a moment, admit that they furnish a basis upon which contracts could be let to the advantage of the Government. The difference between the method of constructing American and Indian railways is exhibited in the excessive allowances for work which could never be required.

Mr. Willcocks is not only an engineer of great ability and indefatigable energy, but deservedly enjoys the reputation of a readiness to adapt his plans to circumstances, in a manner characteristic rather of the United States than of Great Britain. His field work would be very different from his plans on paper. Availing himself of the tremendous velocity obtainable through the Lulu and Safir basins and the rapid slope of over 150 feet into the Raiyān depression much of the excavation would be accomplished by natural forces.

The Raiyān works proper commence at the Bahr Jūsuf and the western (desert) edge of the Nile Valley. Former estimates of £500,000 (\$2,500,000) would not be exceeded. The great canal across the Nile Valley from Biba would in reality be a broad shallow basin cultivable once a year throughout its entire area. The masonry works may be taken as reasonable, but a part of the money would be otherwise expended. The total cost, therefore, of the Raiyān project should be estimated thus:

Raiyān Canal of escape and supply	\$2,500,000
Works in the Nile Valley	1,500,000

Total	(£800,000)	4,000,000
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(7) *Quantity of water capable of being utilized (without pumping).* Time of filling reservoir.—It appears (from Mr. Willcocks's tables) that for 40 days each flood a depth of water of 8 metres (25 feet) may be taken into the canal, for 20 days the basins above the canal may be discharged into the canal through the Bahr Jūsuf, for the 30 days of November a depth of 6 metres of water may be counted on, for December a mean depth

of 4.5 metres, for January a depth of 3 metres, and for February of 2 metres. With an 80-metre wide canal slope $\frac{1}{1000}$, the (daily) discharges are :

	Cubic metres.
8 metres depth	67,000,000
6 metres depth	42,000,000
4.5 metres depth	25,000,000
3 metres depth	13,000,000
2 metres depth	6,000,000

Therefore the supply obtained per annum would be :

	Cubic metres.
September and October	$60 \times 67,000,000 = 4,020,000,000$
November	$30 \times 42,000,000 = 1,260,000,000$
December	$30 \times 25,000,000 = 750,000,000$
January	$30 \times 13,000,000 = 390,000,000$
February	$30 \times 6,000,000 = 180,000,000$
March, from Bahr Jūsuf	$30 \times 5,000,000 = 150,000,000$
Per annum	6,750,000,000

Referring to the table of contents of the Raiyān depression, and allowing for evaporation and absorption, it appears that the water in the lake would rise to—

	Metres above sea.	Contents cubic metres.
At the end of the first year	+ 2 =	6,750,000,000
At the end of the second year	+17 =	12,892,100,000
At the end of the third year	+27 =	18,566,760,000

In other words, the lake would be filled to the level +27 metres (above sea), or about 5 metres (16 feet) above low Nile at the end of the third year. It could give a half supply that year. The fourth year the lake would be in full working order and could be filled to +28 metres. Allowing 1 metre as loss by evaporation from April 1 to July 31 (an excessive estimate), the water in the reservoir could be utilized (without pumping, either to fill or empty), to the depth of 2 metres, i. e., a stratum of water of 1,263,920,000 cubic metres, or a discharge of 12,639,200 cubic metres per day (about 3,000 million gallons for 100 days). This amount would flow back into the (Nile) canal through the reservoir canal as levels would suit. There are years when the lake could be filled to river level 29 or river level 30 but above river level +28 could not ordinarily be counted on.

It is obvious that Mr. Willcocks does not mean to limit the available portion of the 20,000 million cubic metres stored in the Raiyān reservoir to little more than one-tenth. The water is to be consumed at all levels above the Mediterranean on its way to Alexandria, Port Said, or Suez, and even slightly below the level of the sea on the bed of Lake Abūkir. A straight, clear channel past the pyramids, connecting with the Alexandrian canals, would lower the lake another 5 metres without artificial means.

(8 and 9.) *The quality of the water, and its effect on the summer water of the Nile.*—Mr. Willcocks quotes at length from the report of a meeting of the Khedivial Geographical Society, March 16, 1889, in which this and kindred points were fully discussed.

Pierre Bey, engineer-in-chief of the Compagnie Eaux du Caire, inquired whether there was any danger of infiltration into the Fayoum. M. Lieurnur, engineer-in-chief of the expedition of 1883, responded, and pointed out that it was definitely settled that the two depressions are everywhere separated by broad and solid strata of rock, except at two narrow passes of inconsiderable width, and little below the level of high Nile. In answer to a second question, whether the lake might lose a part of its contents by infiltration towards the Mediterranean, he said that as the Raiyān and Fayoum basins, although 40 metres below the sea, have no infiltration into them, such a risk could not be considered as within the range of possibility.

It may be added that the silt-charged waters of the Nile speedily fill interstices and thus canals and embankments puddle themselves.

Salem Pasha (the largest landed proprietor in the Gharaq district) desired to know whether the water might not be impregnated with salt. Mr. Cope Whitehouse replied that this subject had been attentively considered, and that the unanimous conclusion of the officials in the irrigation department, as well as the native chief engineers, whom he had taken pains to consult, was in the negative. There is salt in the Raiyān basin as everywhere else in Egypt, on the tops of its hills and in the soil of its fields. A shallow lake would be brackish. The Birket el-Qerūn when low is quite brackish. It contains all the salt which has passed into the Fayoum for countless ages, from a prehistoric period, concentrated from a surface of 1,250 square miles into a comparatively small area with a depth of only 8 metres (25 feet). Whenever this lake has attained a greater depth the upper stratum has become quite fresh, as evidenced by

the remains of shell-fish. Even now the upper stratum can be used to drink; he had often so used it for several days at a time. The bed of the Raiyân basin contains in certain places small saline deposits. The pools formed in the lowest parts would be brackish until they had attained a certain depth. When the lake had been filled to a depth of, say, 20 metres, the water would be quite fresh. The large quantity added and withdrawn each year would also tend to change the whole volume, while any percentage of salt absorbed would be infinitesimal, and of no possible importance in relation to either agriculture or its use in drinking.

Dr. Schweinfurth was inclined to think that the Raiyân depression could be more advantageously treated like the Fayoum, and used as an additional cultivated area. He repeated the fear that the water might become salt.

Mr. Cope Whitehouse said, in reply, that the difference between 80,000 (Egyptian) acres, cultivated once a year, and (not less than) 2,300,000 acres of *sefi* (summer) cultivation was in itself a reason why the reservoir scheme must be considered preferable, if feasible. In any event there is no risk incurred. Long before any part of the water which had been poured into the Raiyân basin could be discharged again into the Nile, the problem would have received a practical and final solution. If the water proved unfit for use, the canal would nevertheless have paid for itself as a flood escape, and as an irrigation canal for the Raiyân district. He might also say that if the Raiyân basin was the Lake Moeris of the Ptolemaic maps, we have the experience of 2,000 years to put against a conjectured possibility. He would, however, ask the inspector-general of irrigation for his opinion.

Major (now lieutenant-colonel) Ross—who was received with warm applause—said that he entertained no apprehensions in regard to the purity of the waters and explained his reasons at length.

He wished to add, in respect to the amount of land which could be cultivated by this reservoir, that Mr. Cope Whitehouse had confined himself to the Delta. If 20,000,000 cubic metres of water per diem could be added to the summer supply, it would enable the department of public works to increase the amount now allotted to the cultivation of Upper Egypt. There is also a large area in the plain near Kom Ombos, which, by the scheme recommended by Mr. de la Motte, would be converted into a storage reservoir. It is excellent land, and can be easily irrigated. *Sefi* cultivation might be largely extended in the provinces of Minieh and Beni-Suef. Cultivation in the Fayoum could also be increased. The Government would not be obliged to economize its water supply in Upper Egypt, because the Delta would obtain a part of its normal as well as an additional supply from the Raiyân reservoir. Another 10,000,000 cubic metres of daily supply would also go far to put a stop to corruption in the Delta. The strain upon the honesty of the local officials, when offered a bribe for a few hours' more water, is very great and sometimes irresistible.

Mr. Lieurnur confirmed what had been said by Major Ross in regard to salt. In accordance with his instructions he had sunk experimental wells all over the basin, and had not found salt except in insignificant quantity. The bottom of the basin is rock covered with clay and drifted sand-hills.

On this point it may be added that it is much to be regretted that Dr. Schweinfurth should have given expression to a doubt on this subject. The question was subsequently examined by Osman Bey Ghalib and Dr. Seckenberger, and they agree with Colonel Ross and all other experts. No project has probably ever met with such universal favor as this Raiyân scheme. Thousands of engineers, American, Egyptian, English, French, and German, have had an opportunity of studying it. The most eminent men have urged its immediate execution. Objections of a somewhat similar character, transmitted through Sir E. Baring, British agent and consul-general, to the foreign office, have contributed materially to delay the actual completion of the work. "The purpose of the Government," says Herodotus, "in constructing this reservoir was to supply (good) Nile water to the inhabitants of the towns not lying upon the main branches of the river; for previously they had been obliged after the subsidence of the flood (as at present) to drink a brackish water which they obtained from the wells."

(10) *Passage of the Raiyân water through the canals of Lower Egypt.*—The canals taking off from above the Barrage will be capable of utilizing the following discharges at river level 14 metres on the Barrage, which is the maximum gauge to which water is to be held up in summer:

	Cubic metres.
Behêra, (per day)	8,000,000
Menoufeh and Gharbieh (per day)	16,000,000
Dakalia, Sharkia, and Kalubia	20,000,000
Total	44,000,000

Since the mean summer discharge of the Nile at Cairo is 34,000,000 cubic metres per

day, and the reservoir can supply at least 12,000,000 per day in summer, the existing canals will (to that extent) suffice.

(11) *The lands to be reclaimed near the sea* will have to be provided with canals and drains. An expenditure of £2 (\$10) per acre on the land to be reclaimed must be considered in all estimates of cost of reclamation, in addition to the water supply in summer. The winter supply will have to be provided against also in some of the provinces.

(12) *Cost of the project and time required.*—Mr. Willcocks estimates the cost at £1,589,000, if everything has to be done thoroughly. The canal will, he thinks, take three years to complete if machinery is freely employed; and the reservoir will take three years to fill.

Prime cost.....	£1,589,000 = \$7,945,000
Interest at 5 per cent. for six years	476,000 = 12,383,000

Total cost, including interest.....	2,065,000 = 10,328,000
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How can interest be calculated on the entire total cost for the three years in which the works are in progress? The interest the first year would not be £10,000, and the ordinary deferred payments to the contractors would still further effect material reduction.

The Manchester Ship-Canal has established a rate of excavation and earthwork which would enable a contractor of equal energy to open the canal of escape in a single year. It would immediately begin to earn the amount agreed upon as remuneration for this part of its duty. The small basin, the Lulu Reservoir, would be also available for storage, and a crop grown on the plateaus of the Raiyān depression wherever water lodged for over 10 days.

The masonry works would not be required until the third year after the escape canal had been completed, and it would be inexpedient to undertake them until after the escape had been worked. Official estimates are influenced by precisely the opposite calculations to those which induce the capitalist to add 50 per cent. to the figures of an ordinary project. The British Government desires to increase the Egyptian debt, without guaranteeing either principal or interest. It has been proposed to use the Raiyān project to influence the great powers. The liberty to borrow a large sum would be convenient. If the works were executed for half the estimates there would be so much more to the credit of the irrigation department.

Mr. Willcocks concedes that, by carefully selecting the site of the canal and economizing in the hill slopes, the total cost (of the completed works) might be reduced to £1,800,000 (\$9,000,000). The annual interest charge would then be, at 5 per cent., £90,000 per annum. Nothing is said about maintenance charges, probably because he considers them too insignificant.

This undertaking appears (to him) so vast, and the difficulty of insuring a return so great that no private company, except a guaranteed one, could undertake it. "As far as Egypt is concerned, however," he says, "the completion of this reservoir would permit of a new province being formed in the north of Egypt, and give an impetus to the reclamation of the waste land which would in the end have a marked effect on the revenues of the country. With flush irrigation in summer assured land could easily pay ten shillings (\$2.50) per acre. With a canal of 80 metres in width a discharge of 12,000,000 cubic metres per day in summer can be guaranteed for £1,800,000 (\$9,000,000.) The interest on £1,800,000 at 5 per cent. per annum is £90,000 (\$450,000), or £75 (\$375) per million cubic metres (400 feet a second). Twelve million cubic metres per day would suffice for 300,000 acres of rice, or 400,000 acres of rice and cotton combined. To reclaim 400,000 acres it would be necessary to spend £2 (\$10) per acre, or a capital of £800,000 (\$4,000,000). A company, therefore, which received the concession of the Raiyān reservoir and 400,000 acres of land in the Birriya (uncultivated Delta) would need a capital of £2,600,000 (\$13,000,000). If the undertaking were successful a net profit of 15 per cent. might be obtained, but the company would always be at the mercy of the Government."

It seemed better to give the summary of the projected restoration of the Raiyān Moeris (as far as possible) in the words of Mr. Willcocks. Everything that he concedes in its favor is clearly to be accepted as the official admission of men of marked ability, enjoying every opportunity of arriving at correct results. In the opinion of the Hon. John Cardwell, late consul-general of the United States, himself a warm sympathizer in my efforts, the project was reluctantly examined with the expectation and hope that it might easily be exposed as a delusion.

No capitalist, of course, would raise the money in the form contemplated by Mr. Willcocks. The money required for canals and drains in the Delta could be obtained from local enterprise. No guaranty would be required from the Government except an undertaking to allow water to flow in and out of the canal at certain stages of

the river, and to pay, at fixed rate per million cubic metres, for the benefits thus conferred.

Sir C. C. Scott-Moncrieff is in this dilemma: If he advises the Egyptian Government to solicit from the great powers the right to increase the indebtedness of Egypt, he pledges his position and reputation to the absolute certainty of the enterprise. He knows that every penny wrung from the peasant is a hardship, and that the power of Egypt to borrow at between 4 and 5 per cent. would be seriously strained by the unprofitable use of any such sum of money as £2,000,900. Taking only the absurdly small estimate of £5,000,000 (\$30,000,000) as the total cash value of the Raiyân reservoir, Mr. Willcocks estimates my gift to Egypt at £4,000,000 (\$20,000,000); the actual value, of course, with skillful management, would approach £100,000,000 (\$500,000,000).

If, on the other hand, there is any risk, what is it? What is its value in terms of enhanced interest or prospective profits offered to the capitalists? Let Sir C. C. Scott-Moncrieff draw up the terms of a concession, or modify those already submitted. They embraced the alternative of lending the Government the necessary funds, without a guaranty, on participation in net earnings, or of completing the works in one-half the time, and at one-half the cost, on which Mr. Willcocks would earn 15 per cent., and Sir C. C. Scott-Moncrieff concedes 10 per cent. It may be observed that no allowance is ever made for any remuneration to the discoverer, inventor, or advocate of the Raiyân project.

Vastness is no attribute of the engineering works detailed by Mr. Willcocks. The original scheme, including the conversion of the Fayoum into a fertile province, with its borders and approaches crowned with pyramids and a pyramid hill where it was deepest, a canal—a river, not a stagnant ditch—from Assiût to Alexandria, fit channel for Indo-Mediterranean commerce, passing at the foot of Memphis, a throne of empire, was vast in every sense of the term. Some elements of the sublime might be thought to attach to the pursuit of the true, the beautiful, and the good—the defense of the dead from aspersion, and of the living from pestilence and famine. The removal of some millions of baskets of earth is literally child's work.

"In spite of much ridicule and some opposition," writes Mr. Moberly Bell, "Mr. Cope Whitehouse has held to his project with all the tenacity of an enthusiast, and has now the well-earned reward of seeing his scheme regarded as practicable and profitable by men whose judgments can not lie under the suspicion of being influenced by the poetical enthusiasm of the student who originated them. It is probable that if he had appeared in Egypt as the mercenary would-be promoter of a simple commercial enterprise his views would from the first have received more serious consideration. It is, however, at least equally probable that they would not have achieved the same success. He may now be fairly congratulated on having proved the practicability of a scheme which was by many regarded as the dream of the visionary enthusiast."

Sir Edgar Vincent, as financial adviser to the Khedive, in his memorandum on the subject (1888) said: "If, after the Barrage has been working for 3 or 4 years, it is found that an increased supply of water is required and can be dealt with, the scheme of Mr. Cope Whitehouse will become a valuable instrument for the agricultural development of Egypt. If it were possible to make the scheme entirely self-supporting by granting Mr. Cope Whitehouse, for a term of years, certain barren lands which his reservoir would render cultivable, such a proposal would have my hearty support." He added with generous courtesy: "I can not conclude this memorandum without expressing my high sense of the intelligence and perseverance with which Mr. Cope Whitehouse has pursued the realization of his object."

Sir Julian Panncoft, as permanent under secretary of state for foreign affairs, on January 12, 1889, wrote: "With reference to my letter of the 13th of August last, and to previous correspondence respecting your scheme for the creation of a large reservoir in the Raiyân basin for the storage of Nile water for irrigation purposes, I am directed by the Marquis of Salisbury to inform you that Her Majesty's agent and consul-general at Cairo (Sir Evelyn Baring) has received a note from the Egyptian minister for foreign affairs (Zulfikar Pasha) stating that the project has been carefully examined by the Egyptian Government, but that after full consideration they have come to the conclusion that they can not adopt your proposals, while the benefits which might accrue from their adoption are fully acknowledged. I am to add that Her Majesty's agent and consul-general, while regretting that Egypt is not able to profit by the execution of the project which you have prepared with so much care and skill, states that he has satisfied himself that the project has been considered with the greatest care and attention by Sir C. C. Scott-Moncrieff and Colonel Ross, who, as you are aware, are the responsible advisers of the Khedivial Government in such matters."

The Raiyân project, then, is in "a complete and perfect state" (Willcocks, p. 322). The Khedive, as befits the ruler of Egypt, displays that disposition to further its execution which his judgment, tact, and practical acquaintance with the needs of his people approve. The native officials and the inhabitants coöperate. The British

Government assumes all the responsibility for the delay, basing the attitude on the recommendations of its representative. Sir Evelyn Baring has authorized me to make public his personal recognition of the value of the work, and expression of regret that circumstances should not permit it to proceed as rapidly as seems to me desirable.

Lord Salisbury has given the subject some attention, but whether from recondite motives of profound policy, or influenced by the qualified, and in some respects erroneous, information laid before him, this most able of foreign secretaries has not allowed his hand to close upon the powerful weapon which has for some time been well within his reach.

Mr. Gladstone, with his keen love of Hellenic literature, has thrice sought occasion to offer words of encouragement and commendation. On both sides of the House of Commons, but especially from the Liberal side, assurances have been given that this question would never be treated as political.

The King of the Belgians early manifested a personal interest, expressed in terms which were flattering in the extreme.

The French Government also, I am credibly informed, would further the project as tending to improve the state of Egypt without regard to purely political considerations.

If, as Sir Samuel Baker points out in the *Fortnightly Review*, October, 1889, every river tributary to the Nile should be controlled by weirs or dams of masonry, "the scheme for the restoration of Lake Moeris (in the Raiyān depression) as the great reservoir of the Nile, proposed by Mr. Cope Whitehouse for the security of Lower Egypt, would be accomplished as a natural result of engineering science, which had bridled the untrained jaws of Egypt's river, and guided its course to the service of mankind." A true fountain of the sun, it would bring light and life to the heart of Africa. It would once more challenge the admiration and esteem of the world for those who thought that by such great works they reared an imperishable memorial to attest the splendor of noble purpose when applied to guide and restrain the capricious hand of nature for the health and wealth of the distressed inhabitants of the valley of the Nile.

NOTE.—The author of this paper is not responsible for the spelling of the names in quotations, or on the maps and cuts reproduced.

MADAGASCAR.

REPORT BY CONSUL CAMPBELL, OF TAMATAVE.

There is no land in this country brought under any regular or practical system of irrigation. The natives raise nothing for exportation, and the few commodities that are exported in the shape of India rubber and roffia grow spontaneously and are indigenous to the soil. The chief exports are dry salted hides to the United States, and oxen to Mauritius, and Re-union.

The sources of water supply come from the rivers and streams, there being no reservoirs or other water receptacles in the country. When the natives need the water for the flooding of the ricefields they conduct it in the most primitive manner through shallow channels constructed from grass and mud, or any other material they find close at hand.

Water is used without restrictions, and every man may use as much as his ricefield needs, having nothing to pay for its use. The water would appear to be community property.

The character of the climate in the rice-producing regions is temperate and the nature of the soil is rather of an adobe character.

The antiquity to the irrigation would appear to have commenced with the Hova ascendancy in the country, and there are no expenses connected with it except the labor required in cultivating the rice crop.

JOHN P. CAMPBELL,

Consul.

UNITED STATES CONSULATE,

Tamatave, September 9, 1889.

MADEIRA.

REPORT BY CONSUL JONES, OF FUNCHAL.

AREA IRRIGATED.

The area of Madeira is about 240 square miles. About one-half of the island is in cultivation. The whole of the seaboard is more or less cultivated by irrigation. Where water is plentiful, such crops as sweet potatoes, beans, cabbages, etc., are grown as high as 3,000 feet elevation above the sea, but maize is seldom grown above 800 to 1,000 feet, owing to the short summer season on the hills. The area which is under cultivation by irrigation with sugar cane, potatoes, onions, maize, etc., and almost at all seasons, and where therefore the population is concentrated, varies between 500 and 1,500 feet above sea level, and may be estimated at a little more than one-third of the whole area of the island.

It is difficult to estimate the quantity of the crops grown, as the exports are pretty well limited to sugar, wine, onions, potatoes, and bananas. Sweet potatoes, which is probably the largest crop grown, beans, cabbages, etc., are consumed in the home market.

Almost all the cereals and food plants are grown in Madeira.

The wheat is of the bearded kind, with a hard semi-transparent grain, and commands a better price than the imported. A large part of the vegetable subsistence is derived from the pumpkin tribe.

The banana is one of the best paying crops. It is confined below the 500 feet line. Oranges grow at an elevation of 1,500 feet.

WATER SUPPLY.

The water supply is derived from perennial springs, and from the many gorges, which carry off the water from the hills to the sea during the rainy season. After May, these gorge streams are quite dry long before they reach the sea, their water having been drawn off by the different levadas.

The north side of the island, being more precipitous and well wooded, supplies its different levadas, as well as several of those on the south side.

There are no reservoirs or catchment basins. They would be expensive to make, owing to the precipitous nature of the hills, and it is doubtful whether the broken and rock hillsides would hold the water unless the whole bottom were concreted.

IRRIGATION WORKS.

The character of the works used for distribution of irrigation water are levadas or open culverts. These are constructed of masonry, or cut in solid rock at high levels. They pass through tunnels, over bridges, and along the sides of precipitous mountains, carrying the water to the cultivated lands below.

Some of these levadas are a few miles in length, while others are 60 and 70 miles long.

The system of water distribution is governed by custom, and the flow is rated by the hour. Some levadas deliver their whole contents during an hour or more, as the proprietors of the water may be entitled to have it. Others deliver, say, one quarter of their contents at a time.

The irrigator only requires the quantity of water at a time which will run along a furrow without washing the soil away.

The St. Luzia levada, for instance, contains 4,245 hours of water, to which there are proprietary rights acquired by purchase from the original makers or by inheritance. It now takes 50 days for each proprietor of one hour to have his turn again, but he receives it instead by the quarter every 12½ days.

Besides the proprietary right, there is in all levadas a right of water which belongs to the levada, and the committee of management for the year sells this water in January for the benefit of the levada, for repairs, etc., the water being plentiful at that season.

During the recent sugar-cane disease the price of an hour of water, fell 50 per cent. in the Sta. Luzia Parish, viz: from \$6 to \$3.

Each piece of ground within the district of a given levada is entitled to its hours of use of the stream. For 8 or 9 months of the year the water is turned on to the proprietors as they may desire it; but when the dry season sets in the committee puts it a "gyre," or space of time occupied in making the tour of the whole district, which gyre varies from 15 to 60 days, according to the extent of the district.

The "levadeiro," or distributor of water, is a salaried official, paid by the committee. He also collects a small fee of about 3 cents per hour per annum of the proprietary rights and a higher fee on rented water.

These fees are fixed annually by the committee.

When extensions or repairs of any magnitude are undertaken the money is borrowed, usually from the proprietors, and paid back in water or by rates levied over preceding years.

The foregoing applies to the old levadas, which were constructed by the proprietors.

No two levadas are alike in their volumes of water, in their velocity, or in their rates. In the neighborhood of Funchal the price of an hour's run in the season is from \$5 to \$8, while on the north side of the island it will never exceed a dollar per hour.

The government has during the last 50 years, constructed levadas which collected the waters in almost inaccessible gorges on the north side of the island, and conducted it to the warm south side. These waters are distributed to the cultivators of the soil at a nominal cost.

But when the government levada is completed and leaves the hands of the department of public works for those of the local, it gradually falls into ruin for want of attention.

No repairs can be made without estimates, and these have to be submitted to Lisbon for approval, and when approved the time is generally so long that the original estimates are insufficient.

WATER DISTRIBUTION.

As water is the most valuable property in Madeira, there is more quarreling about it than about anything else in the island. It is a fruitful source between the well-to-do and the poorer class. More people go to prison for stealing and tampering with water than for anything else.

One of the principal difficulties attending the management of the levadas was the want of a legal standing as corporate bodies of their committees. A quarrel between two levadas drawing their supply from the same valley occasioned a lawsuit, which has lasted now more than 40 years.

Within the last few years a law has been passed enabling the committees to incorporate themselves, with power to acquire property and otherwise protect and improve their levadas. They can purchase the land containing their springs, protect the forest and the trees along their lines.

Every farmer of thrift has on his land tanks to store his water, and from these tanks little levadas distribute it when and wherever he wants it.

Water rights are held under title deeds, which specify the intervals at which the supply shall be given and the length of time it shall continue.

Water is always of ready sale. If a crop fails from any cause the water for that land is sold to a more fortunate neighbor, though sometimes at a very reduced rate, as was the case in the time of the sugar-cane disease.

Under any system it is hard for the poor. Their supply is scant, and they must receive it when their time comes, seasonable or unseasonable, day or night, and without tanks they can not care for or properly distribute it.

CLIMATE AND SOIL.

The irrigated region is the coast belts, which during the summer season will produce crops that will ripen before the early autumn sets in. The nearer the seashore, with its consequent semitropical heat, the more valuable becomes irrigation.

The annual rainfall in Funchal is about 28 inches, but the hills which supply the springs are almost always covered with clouds and wet mist, the water contents of which can not be estimated.

The soil varies in quality. That of the coast belt is calcareous tufa, with an admixture of vegetable matter, and is very rich. Wheat and barley are grown on the same land from generation to generation with hardly any application of manure.

The soil best adapted to the vine is a decomposed red tufa, especially when there is an admixture of stone with it. The hill regions have a stiff clayey soil.

ANTIQUITY OF IRRIGATION.

There are levadas here probably 300 years old, but several of these have had their courses changed during political troubles and from other causes. The levada, for instance, which now irrigates St. Vicente, on the north side of the island, was constructed by the inhabitants of the Brava Valley on the south side, and was lost to them during the interregnum between the Spanish and Portuguese occupation.

NEW GOVERNMENT IRRIGATION WORKS.

The government is now constructing a levada, which will collect its waters in the hitherto quite inaccessible Inferno gorge, for irrigating the St. Vicente Valley, when it will restore to the Brava Valley the levada which originally belonged to it.

The source of this new levada is at the height of 4,700 feet above the sea, and after entering the valley it is intended to throw the water down a series of cascades, with a fall of more than 300 feet.

A constant flow of a pint of water is sufficient to irrigate five acres of ground; that is, the water must flow into a reservoir and be used from that as required.

I have had translated the "regulation for the government of the government levadas of this island," and have had it attached to this report.

There are no maps or drawings of these works obtainable.

The engineers, contractors, and others who build our government levadas come from Lisbon, and the plans, estimates, etc., are kept there in the office of public works. There are no publications that I can find.

Mr. John B. Blandy, of this city, is the largest land and water proprietor on the island. He has had more to do with the construction and working of these water ways, and is probably more of an expert, than any person on the island. I am indebted to him for this report.

THOMAS. C. JONES,
Consul.

UNITED STATES CONSULATE,
Funchal, September 3, 1889.

[Inclosure in Consul Jones's report.]

REGULATIONS FOR THE LEVADAS BELONGING TO THE NATION IN THE DISTRICT OF FUNCHAL—ADMINISTRATION AND MANAGEMENT OF THEIR REVENUES.

PART I.—*The Levadas.*

ART. 1. The regulation of the government levadas in the district of Funchal and the superintendence of the revenues of same are under the surveillance of the treasurer of the same district, according to the decree published on the 10th November, 1849, and the regulations for the administration of the public revenue published on the 28th January, 1850; also a government grant published on the 14th September, 1860.

ART. 2. The levadas that belong to the government in the said district are the following: Rabaçal, in the parish of Calheta; Fajã dos Vinhaticos, in the parish of Santa Anna; Iuncal and Furado, that irrigate Santal Cruz Machico.

ART. 3. The Levada Rabaçal will continue to be divided into two branches, one that irrigates Calheta and Estreito, the other that waters Prazeres and Fajã da Ovelha.

ART. 4. The levada Fajã dos Vinhaticos will continue to be divided into two parts, each containing an equal quantity of water.

ART. 5. The levada Iuncal and Furado are also divided into branches, one that irrigates the parish of Santa Cruz, the other Porto da Cruz.

ART. 6. To superintend the said levadas, there will be appointed a staff of men, to be paid by the treasury of the home government.

ART. 7. The number of men, their rank, and respective salaries for each levada will be as follows:

Levada do Rabaçal.

One director, with a salary of 17 per cent. on the revenues of the levada, calculated to be.....	\$156.67
Two levadeiros (or watermen), at \$24 each.....	48.00
Two caretakers, at 24 cents daily each.....	175.20
Total.....	379.87

Levada Fajã dos Vinhaticos.

One director, with a salary of 8 per cent. on the revenue of the levada.....	\$43.00
Two levadeiros, at \$16 each.....	32.00
One caretaker, at 12 cents per day.....	43.80
Total.....	118.80

Levada Iuncal and Furado.

One director, with a salary of 8 per cent. on the revenue of levada.....	\$44. 16
Two levadeiros, at \$16 each.....	32. 00
One caretaker, at 12 cents per day.....	43. 80
Total	119. 96

ART. 8. Besides the above items, which are for salaries, there will be another item of \$180 yearly to compensate any deficiency in the salaries.

ART. 9. Four directors of the levadas are appointed by government, under the proposal of the treasurer, and keep the appointment as long as they are worthy of it.

ART. 10. The levadeiros are appointed yearly by the delegate of the treasurer under the proposal of their respective directors.

ART. 11. The caretakers are appointed by the delegate of the treasurer under the proposal of their respective directors.

ART. 12. The duties of the director of the levada are permanent, and are as follows:

I.—In the proper season for irrigation he is bound to see that the waters are fairly distributed.

II.—To make as far as it lies in his power all the waters enter into the levada, so that the lessee of the water may have his share or more when his turn comes to irrigate his ground.

III.—To have repaired any small damage made to the levada when necessary, having it in his power to call for help should he be unable to attend immediately to the said repairs.

IV.—To avoid the loss of water should he know it, and give note, etc., of the same to the administrator of any damage done to the levada. If there are damages he may appeal to the department of Government works.

V.—To watch that the duties of the levadeiro and caretaker are properly carried out. The directors of the levada are answerable for its good keeping, and also of the small canals that bring the water from the springs.

ART. 13. The duties of the levadeiro last during the irrigation season only. They are bound to deliver to each lessee the quantity of water that he rents to irrigate his ground, according to a list given him by the clerk or tax collector.

ART. 14. The duties of the caretakers are permanent, and are as follows:

I.—To live close to the levada.

II.—To watch in summer and winter the levadas that they are kept in proper repair, and that the springs are drained so as to enter the levadas.

III.—To keep all the traps of the levada open when it rains.

IV.—To clear all obstacles that are carried by the water that may cause overflow.

V.—To see that the levada is in proper repair and to have repaired any wall that may have fallen over the levada, and to have removed any earth that may obstruct its course.

VI.—To walk the course of the levada continually, or the part that he takes care of, to complain to his director of any theft of water, or of any damage that he can not repair.

VII.—To watch the good keeping of the trees close to the levada.

VIII.—To fulfill all the orders given him by the director as regards the levada.

ART. 15. The caretakers of the levadas are considered as forest keepers, and are bound to watch the forest and bushes of his district, complaining to the administrator of the locality should there be any damage to the forest.

ART. 16. The director of Levada Rabaçal is bound to live close to the same levada in one of the buildings, at a place called Rosadas, and to keep the houses clean when visitors stay there on their way to see the levada, and he is also answerable for the good keeping of the furniture, of which he has an inventory given him by the administrator, of which there is a copy sent to the Government department of the district, and one given to the caretaker of this levada. The director can have a house to live in conditionally that he keeps the tools belonging to the levada and also those of the public works.

PART II.—To lease the waters.

ART. 17. To rent the water, each levada must have a "giro" (that is a rotation of days), so that each lessee during the irrigation season shall receive the quantity of water he bargained for or bought.

The "giros" are fixed as follow: For the Levada Rabaçal is established every 16 days or 384 hours in each branch. For the Levada of Fajã dos Vinhaticos every 16 days or 384 hours in each branch. For the branch of Iuncal and Furado that irrigates Santa Cruz the "giro" is 25 days or 600 hours. For the branch of same levada that irrigates Porto da Cruz the "giro" is 16 days or 384 hours.

ART. 18. The leasing the said waters shall take place yearly in the month of March in the office of the administrator of the locality in presence of the notary of the crown, and besides these, the director and levadeiros chosen by him are to be present to give any information that may be required.

ART. 19. For the said leasing it is necessary that placards signed by the administrator, advertising the day appointed for the lease, should be posted in the most public places of the parish, and at the church doors, stating the "giro" of the levada and the price per hour.

A copy of these placards shall be sent to the vicars of the parish where the levada runs, to be read before the mass is celebrated.

ART. 20. The "giro" of the waters in each levada can only be altered by the Government after the civil governor has given his opinion, and the delegate of the treasurer.

ART. 21. The price of water in each levada is annually fixed by Government according to informations given by the different functionaries.

ART. 22. The lease of these waters is made so as to include the greatest number of landed proprietors whose grounds require water, making a just and equitable distribution of it according to the wants of each individual; those that in former years rented water and paid for it have the preference, and that the quantity demanded is indispensable to the soil under culture to be irrigated.

The water can not be rented to those who are in debt for any of the preceding years.

ART. 23. The notary will take the names of all those that buy water, the quantity of hours bought, and the price which the lessee has to pay, all signing a document in which they bind themselves to pay the amount as soon as it is demanded.

ART. 24. Of the document above mentioned copies are to be made so that they can be sent, one to the treasurer by post, another to the director of the levada, and two others to the levadeiros. These last need not have the amounts of money written on them.

ART. 25. The original of the above document to be kept in the archives of the Government office after the necessary papers for collecting the amounts have been made out.

ART. 26. The day on which the waters are distributed, placards are to be posted in the most public parts of the parish, also on the parish church doors.

PART III.—*To collect the rents.*

ART. 27. The collection of the water rents of the levadas takes place in August and is collected by the tax collector of the parish.

ART. 28. That the lessee may know when the rents are to be paid the tax collector must have placards posted up in the most public places, at least eight days before it commences, giving notice of (1) the place where the rents are to be collected; (2) the name of the collector who is authorized to receive the money; (3) the day on which he commences to receive rents.

ART. 29. The lessee who can not pay during the said period has to pay 3 per cent. on the same amount or a fixed sum of 4 cents when the said amount comes to \$14. The above is declared also in the placards, according to article 20.

ART. 30. The receipt given must be according to model No. 2 of instructions published February 8, 1843.

The list must be made out according to article 24, before mentioned, and must be in the hands of the collector before the 15th of July of each year, according to practice already established.

ART. 31. The sums received from the rents of water will be booked as "revenues of the levadas," and the 3 per cent. on fixed rate as "revenues of the levadas."

PART IV.—*Different dispositions.*

ART. 32. The administrator has the same duties to fulfill as regards the levadas, as he has towards other national properties, to see especially that the services of the levadas are properly performed by those that are intrusted with it.

ART. 33. If the repairs of the levadas be so expensive as to call for the aid of the public works, the administrator of the parish is obliged to inform the delegate of the treasury, that he may ask the civil governor of the district to have the necessary repairs made.

ART. 34. The appointment of the levadeiros must be made yearly by the administrator during the month of February.

ART. 35. The salaries are to be paid every quarter. Other trifling expenses attending repairs to be paid at the end of each month in which they are made.

ART. 36. To pay the salaries of the employé as well as the different items attending the levada repairs, annual pay sheets are to be made by the directors and a special sheet made out by the administrator and sent to the treasurer to be paid.

The balance sheet, to be paid, must be accompanied by the directors' vouchers signed by the administrator.

ART. 37. If at any season the irrigation water is not all sold, the "giro" can not be altered, but the administrator must let the delegate of the treasury know.

ART. 38. If at any time there is not a competent director appointed, the delegate of the treasury in the district may appoint a person *ad interim* until he gets one to fulfill the place definitely. The appointment of the director can be made by the administrator, and in that case he receives the salary of a director.

ART. 39. If the place of caretaker becomes vacant, the director can appoint a person *ad interim*, until he definitely engages an individual; in the mean time he must acquaint the delegate of the treasury of the person he proposes.

ART. TRANSITORY.

To proceed with the lease of waters for the current year the price of water is as follows, subject to the approval of the Government: In the Levada da Fajã dos Vinhaticos and its branches, 70 cents; in the Luncal branch, 60 cents; in the Furado branch, 50 cents.

If at any time the Levada Fajã dos Vinhaticos has not a sufficient quantity of water for irrigation, for example, in the height of summer the two branches are to be united by the mutual consent of both lessees, the price then will be \$1.40 each hour of water, that the lessee receives.

The other levadas are subject to the same conditions when there is a dearth of water, and in that case the price is double.

Home department of the district of Funchal, 28th March, 1862. The delegate of the treasury.

FRANCISCO XAVIER DE SOUSA.

Approved: Home department of the district of Funchal, 7th April, 1884. The first official.

FRANCISCO JOAQUIN PESTANA.

SOUTH AFRICA.

REPORT BY CONSUL HOLLIS, OF CAPE TOWN.

South Africa has been described by some one as a country in which the rivers have no water. This is only too true during a portion of the year, while during the rainy season the rivers have a torrential character and the traveler must perforce halt at the river banks and wait for the rain to run by. Until recently irrigation has been a matter of private enterprise, and the works have been of the simplest and cheapest character. Wherever springs have been found it has been the custom to strengthen them by the building of a primitive dam above the spring's source, and the water to be consumed is then conducted by a system of furrows over the area to be benefited. Where the water of rivers could be utilized the same system of furrows has been followed and narrow strips of land on either bank of the stream are thus brought under a higher system of cultivation, and large crops are the result of such a system.

Irrigation in this primitive way may be said to be the rule in the South African Republic, the Orange Free State, and in a large portion of the Cape Colony. In 1877 the government passed an act for the promotion of irrigation, the principal provisions of which are as follows: Any three or more owners of land within any area in which it is deemed expedient to store water by artificial means for the purpose of irrigation may petition the government to proclaim such area an irri-

gation district, provided such petitioners shall be the owners of not less than one-tenth of the land in such district to be proclaimed. The governor may then dispatch an engineer or other competent person to the locality where a public meeting of land-owners is called, after due notice, and a report is sent to the governor as to the propriety or otherwise of constituting such irrigation district. Should such report be favorable and receive the assent of two-thirds of the owners of land situated within its area, the governor may proclaim such district an irrigation district.

The performance of all acts, etc., relating to irrigation and the storage of water in such proclaimed district shall be vested in a board, having corporate powers, to be chosen from the land-owners of such district. Every owner of land is entitled to vote at an election for members of such board, and shall have one vote for each £500 valuation of land.

The charge and conservation of every natural river, stream, creek, and water course, and of every dam, pond, and embankment within the limits of an irrigation district, which is by its nature common to two or more of the owners of land within such district, and the absolute control and regulation—so far as the same can be effected by artificial means—of the supply of water throughout the course of any such river, stream, etc., within such limits shall be vested in the irrigation board of such district.

Such board shall have power to cleanse, repair, and maintain in a due state of efficiency any stream, river, etc., as above; to deepen or otherwise improve such water course, and to erect dams, reservoirs, etc.; in fact, to maintain, improve, and construct any works that shall be necessary for the proper storage and conservation of water for irrigation purposes.

Provision is made for full compensation for any injury sustained by any person by reason of the exercise of the powers of the board. The board may also enter and take possession of any land, covered or uncovered by water, as may be necessary to carry out the purposes of this act. The board may levy rates at so much per acre in all land within the area which is irrigated or capable of being irrigated, provided that no land shall be taxed that is otherwise irrigated or improved by means contemplated by the act.

Power is given the board to borrow money either by public tender or from funds provided by Parliament, in which latter case the governor may loan to the extent of one-half of the value of the lands, such loan to be a first charge in the same, and he may appoint officers to inspect such lands and works.

Any owner of land not within the limits of any irrigation district, proposing to improve the same by the storage or conservation of water, and desiring a loan from the government for such purpose, may make application for such purpose, giving bonds for the payment of the cost of investigation, and the governor may then cause lands, plans, estimates, and specifications of proposed works to be inspected and reported on. Provision is made for the loaning of money by the government under due restrictions, which becomes a first and preferment charge upon the land at the rate of 8 per cent. for the term of twenty-four years.

Any mortgagee having claim on land must join with the holder of the title thereof in an instrument to be filed with the registrar of deeds. Provision is made for arbitration, the making of by-laws and regulations, and penalties for the fraudulent taking or polluting of the water,

or for obstructing or impeding the flow of water within the area proclaimed.

Two years later an act was passed by which provision was made for the loan of money by the colonial government to municipalities desirous of such assistance in carrying out works of irrigation, the terms of which are similar to the act of 1877, and provides that the interest in such loan shall be provided from the rates levied by the towns availing themselves of the provisions of the act. The act of 1877 was amended in 1880, providing for the advance by the government of the loan made by advances of one fifth of the amount and making provision for repayment of the loan according to the following schedules:

Schedule A.

If the owner shall desire to repay the sum advanced in one or more years, the rent charge shall be (per centum) as follows:

	£	s.	d.		£	s.	d.
One year.....	106	0	0	Thirteen years.....	11	6	0
Two years.....	54	11	0	Fourteen years.....	10	15	6
Three years.....	37	8	6	Fifteen years.....	10	6	0
Four years.....	28	17	6	Sixteen years.....	9	18	0
Five years.....	23	15	0	Seventeen years.....	9	11	0
Six years.....	20	7	0	Eighteen years.....	9	5	0
Seven years.....	17	19	0	Nineteen years.....	8	19	6
Eight years.....	16	2	6	Twenty years.....	8	14	6
Nine years.....	14	14	6	Twenty-one years.....	8	10	6
Ten years.....	13	12	0	Twenty-two years.....	8	6	6
Eleven years.....	12	14	0	Twenty-three years.....	8	3	0
Twelve years.....	11	19	0				

Schedule B.

The present value of every £1 per annum rent-charge shall be—

	£	s.	d.		£	s.	d.
Six years.....	4	18	4	Fifteen years.....	9	14	3
Seven years.....	5	11	8	Sixteen years.....	10	2	2
Eight years.....	6	4	3	Seventeen years.....	10	9	7
Nine years.....	6	16	1	Eighteen years.....	10	16	7
Ten years.....	7	7	3	Nineteen years.....	11	3	2
Eleven years.....	7	17	9	Twenty years.....	11	9	5
Twelve years.....	8	7	9	Twenty-one years.....	11	15	4
Thirteen years.....	8	17	1	Twenty-two years.....	12	0	10
Fourteen years.....	9	5	11	Twenty-three years.....	12	6	1

As early as December, 1881, no less than sixty applications had been made by the districts desiring to avail themselves of the terms offered by the Government. Owing to the peculiar character of the topographical features of the country and the fact that most of the rivers of South Africa are dry in the summer and flooded during the rainy season, a vast deal of scientific labor must be expended in order to determine the sites most advantageously situated for the construction of storage basins and other irrigation works. Topographical and geological surveys are being made under the direction of the Government. It will probably be found necessary to make the formation of water boards compulsory, so that these landowners situated above areas already proclaimed will be amenable to Government supervision in the conservation of their water courses. Wherever irrigation has been properly tried in the colony it has met with unqualified success, assuring large crops to the husbandman and guaranteeing the stock raiser against loss by drought. From the lamentable reports now coming in from the up country of the great loss of sheep by reason of the almost total lack of rainfall this winter, I should judge

a great impetus will be given to this question. Many farmers have reported a loss of from 10 to 50 per cent. of their stock, which would not have occurred had the districts been secured against drought by storage basins. Some idea of the enhanced value of irrigated land may be seen in the report made by one owner who stated that his increased rentals would repay the loan in 4 years.

The most complete storage work completed in this colony, and the most important, is that at Van Wycks Vley. The rainfall in this section is very irregular, the average for 11 years having been 10 inches and in some years falling to 3 and 4 inches. The reservoir has depended on the catchment area of, say, 240 square miles. This has been found to be insufficient for a full supply and a furrow is now nearly completed through which the water of a neighboring river will be brought in, by which it is estimated that the water-covered area will be increased to 19 square miles with a depth of 27 feet. The land under irrigation is held by the Government and is leased at a minimum price of 10 shillings per acre. The bailiff in charge has the sole control of the flow of water and uses his discretion in its supply, some land within the area requiring more water than other portions. Owing to many causes, the chief of which was ignorance of the character of the land, fostered by the report of interested persons who declared that the water would prove to be too salt for agricultural purposes, and who desired the work should fail and be abandoned, giving them a chance to acquire it, the poorest tenants, mostly assisted by the Government supplying seeds, were alone secured. Their success has, however, been so marvelous that the lands will soon be eagerly sought after. It is estimated that last year 1,300 acres were irrigated at an expenditure of an inch of water per month from the surface. The rainfall over the whole colony is so irregular that I have taken the subdivisions of the colony for the purpose of comparison and have summarized the reports from an average of six stations in each district. The rainfall for these districts for the year 1888 was as follows, in inches:

No. 1.—Cape Peninsula	53.84	No. 7.—East Central Karroo	16.15
No. 2.—Southwest	32.95	No. 8.—Northern Karroo	11.43
No. 3.—West Coast	15.18	No. 9.—Northern Border	8.84
No. 4.—South Coast	33.60	No. 10.—Southeast	28.17
No. 5.—Southern Karroo	17.59	No. 11.—Northeast	20.39
No. 6.—West Central Karroo	14.12	No. 12.—Transkei	25.00

The topographical features of South Africa are so peculiar that the system answering for one district is not applicable to others, while the rainfall varies greatly as one leaves the coast and ascends to the various table-lands. In general it may be said that the land being almost entirely denuded of trees and bush, the rain is not drank up by the soil, but runs rapidly over the surface, seeking its natural outlet to the sea, while the evaporation is very great, estimated at 6 feet at Van Wycks Vley, necessitating deep storage basins.

Streams which are alive the whole year are very few.

Boring for water has not been attempted on a large scale, but the experiments made in certain sections have given very encouraging results.

GEO. F. HOLLIS,
Consul.

UNITED STATES CONSULATE,
Cape Town, September 20, 1889.

CONTINENT OF AMERICA.

ARGENTINE REPUBLIC.

REPORT BY CONSUL BAKER, OF BUENOS AYRES.

ANTIQUITY OF IRRIGATION IN SOUTH AMERICA.

In regard to antiquity, I have to say that the artificial watering of the earth to increase its fruitfulness is of so remote an origin in South America that its history is quite unknown. It has been generally assumed that the practice had its beginning in the Orient, and we know that in the days of the patriarchs various contrivances for flooding the fields and meadows were in general use. It was not, however, until the end of the seventeenth century that water meadows were constructed in Europe upon anything like a scientific system, and only towards the end of the eighteenth century that any great improvements took place in this branch of agriculture.

In South America, on the contrary, it is evident that a scientific system of flooding, which consisted in spreading a sheet of water over cultivated fields in such a manner that it could be readily withdrawn, was not only practiced by the aborigines of the country from the most remote period, but that it was done with an amount of precision and knowledge which even to this day are matters of wonder to those who inspect the remains of their works. It seems hardly possible that the natives of Peru and Bolivia and of the eastern slopes of the Andes, which now constitute a part of the Argentine Republic, could have acquired their skill from the nations of antiquity beyond the Atlantic; and hence we are at a loss to understand how such a people, without a long previous civilization, far in advance of their condition when their Spanish conquerors arrived, could not merely have solved the problem of the artificial watering of the land to increase its productiveness, but constructed aqueducts and reservoirs to that end, on such an immense scale and in such an enduring manner that they have defied the changes and vicissitudes of unnumbered centuries. When they were built we do not know; but their remains abundantly prove that the inhabitants, from an unknown date, were well versed in many of the ways and means of civilized life; that they pursued husbandry and practiced agriculture on scientific principles, and that, in defiance of the general absence of rain, they succeeded in producing bountiful harvests even on the precipitous sides of the sterile Sierras. The historian of the conquest of the country refers to the knowledge of agriculture possessed by the primitive inhabitants and the wonderful works of irrigation constructed by them in such a manner as to prompt me to make a quotation from his pages. He says:

ANCIENT WORKS OF THE AZTECS.

Much of the country suffered for want of water, as little or no rain fell, and the few streams in their short and hurried course from the mountains exerted only a very limited influence on the wide extent of territory. The soil it is true, was for the most part sandy and sterile; but many places were capable of being reclaimed, and, indeed, needed only to be properly irrigated to be susceptible of extraordinary production. To these spots water was conveyed by means of canals and subterraneous aqueducts, executed on a noble scale. They consisted of large slabs of freestone nicely fitted together without cement, and discharged a volume of water sufficient, by means of latent ducts or sluices, to moisten the lands in their lower level, through which they passed. Some of these aqueducts were of great length. One that traversed the district of Condesuyos measured between 400 and 500 miles. They were brought from some lake or natural reservoir in the heart of the mountains, and were fed at intervals by other basins which lay in their route along the slopes of the Sierra. In their descent a passage was sometimes opened through rocks, and this without the aid of iron tools; impracticable mountains were to be turned, rivers and marshes to be crossed; in short, the same obstacles were to be encountered as in the construction of their mighty roads.

Most of these beneficent works of the Incas were suffered to go to decay by their Spanish conquerors. In some spots the waters are still left to flow in their silent subterraneous channels, whose windings and whose sources have been alike unexplored. Others, though partially dilapidated and closed up with rubbish and the rank vegetation of the soil, still betray their course by occasional patches of fertility. Such are the remains in the valley of Nasca, a fruitful spot that lies between long tracts of desert, where the ancient water courses of the Incas, measuring 4 or 5 feet in depth by 3 in width, and formed of large blocks of uncemented masonry, are conducted from an unknown distance.

The greatest care was taken that every occupant of the land through which these streams passed should enjoy the benefit of them. The quantity of water allotted to each was prescribed by law, and the royal overseers superintended the distribution, and saw that it was faithfully applied to the irrigation of the ground.—[Prescott's Conquest of Peru, Vol. 1, pp. 131-133.]

Patches of these prehistoric works are also still to be found in the provinces of Mendoza, San Juan, and the upper Andine provinces of the Argentine Republic, though the ravages of time and the reckless indifference of the first conquerors of the country have in nearly every instance reduced them to ruins.

IRRIGATION AFTER THE CONQUEST.

If, however, the early Spanish colonists were more intent in their search for gold than in that for the riches which agriculture produces, their descendants in those far Andine provinces slowly awakened to the fact that the only return they would ever be able to get for their labor would be from the cultivation of the soil. While throughout the pampas, consisting of the provinces of Buenos Ayres, Santo Fé, and Entre Rios, the people followed the lazy but lucrative employment of breeding cattle, to the entire neglect or abandonment of agriculture, which exacted more hard labor and patience than they were inclined to give it, in the far interior provinces, where, owing to the lack of seasonal rains, there was a general absence of pasturage and cattle were unable to feed themselves, the colonists were compelled from necessity to direct themselves to agriculture; but they did it in such a way that, compared with the science displayed by the aborigines, the cultivation of the soil actually retrograded. Mr. Nap, in his work on the Argentine Republic, says:

While the country was a Spanish colony agriculture was neglected to the greatest degree, even in those districts where it had previously been the principal occupation of the primitive inhabitants.

Indeed, the *conquistadores* of the Argentine Republic found there an indigenous population, more numerous than themselves, which if it was not quite so far advanced in

agriculture as the ancient inhabitants of Peru, had adopted many of their ways and usages in regard to irrigation and were especially experienced in the cultivation of the soil. The Spaniards, failing in their search for gold, were compelled to accommodate themselves to the circumstances which surrounded them. Thus they adopted the customs and habits of life of the natives and partially undertook agriculture; and though it was not vigorously exploited, yet it became of a certain importance.

Thus, when the towns increased and a greater consumption was required, the pampa provinces were provided with cereals from the provinces of the interior. For example, the far distant province of San Juan, as late as the year 1860, still sent flour to the Atlantic coast, and notwithstanding the high cost of the transportation by land it was yet able to compete with that of North America, and even surpass it in quality.

But owing to droughts and the constant want of timely rains it was absolutely necessary to secure the necessary moisture by the artificial means of irrigation. And yet it is unfortunately the case that in some of those provinces so little attention was paid to the proper systems of irrigation that these means for watering the fields were actually worse under the Spanish dominion than they were before the period of the conquest.

Since the organization of the Argentine Republic as an independent government, while agriculture was scarcely thought of in the pampa provinces until recent years, the cultivation of the soil has continued to be the principal occupation of the inhabitants of the interior provinces. And it is only in those of Mendoza, San Juan, Catamarca, Santiago del Estero, Tucuman, Salta, and Jujuy that any attention is at all paid to the subject of irrigation. Indeed, but for such artificial means, owing to the lack of rains, it would be impossible to raise crops at all in any of them.

CLIMATE AND RAINFALL OF THE INTERIOR.

In regard to the character of the climate, it will be borne in mind that the Argentine Republic extends from 56° to 20° south latitude, and consequently, in such a wide zone, is subject to a very great variety of climatic conditions. While the far northern provinces have quite a tropical temperature, and the Cuyo provinces have a temperate climate, those portions of the country which extend towards the Straits of Magellan have about six months of quite severe winter. I may also add that the mountain ranges, gradually rising on the west to the regions of perpetual snow, have great effects upon the temperature, even in regions of the same latitude. On this account, in compliance with the instructions of your circular, I shall have to give the character of the climate and the quantity of rainfall for the different interior provinces separately, beginning with Mendoza.

Province of Mendoza.—This province is bounded on the west by the line dividing Chile from the Argentine Republic, and contains about 155,745 square kilometres. A large portion of it is without population. The cultivated portions are mostly in the neighborhood of Mendoza, its only city, which is in latitude $32^{\circ} 55'$ and longitude $68^{\circ} 49'$, and stands at an altitude of 799 metres above the sea. It is situated in the foothills of the Andes. The meteorological office reports for the year 1886 the mean monthly temperature (centigrade thermometer) as follows:

	Degrees.		Degrees.
January	23. 21	July	7. 85
February	22. 83	August	9. 79
March	20. 02	September	12. 87
April	15. 18	October	17. 04
May	10. 55	November	20. 99
June	7. 63	December	23. 65

The mean temperature was $15^{\circ}.99$. The lowest temperature was $7^{\circ}.5$ below zero, on the 8th of August, and the highest $41^{\circ}.5$ above, on the 12th of December, a variation of 49° .

In regard to the rainfall we have returns of the years 1877, 1878, 1879, and 1880, as follows:

Months.	1877.	1878.	1879.	1880.
	<i>Mm.</i>	<i>Mm.</i>	<i>Mm.</i>	<i>Mm.</i>
January	12.0		0.3	0.5
February	5.5	11.0	3.3	9.0
March	0.4	7.0	97.9	23.2
April	18.5	2.0	5.0	
May		3.0		
June			14.0	7.5
July	0.2	18.0		9.0
August		9.0	10.0	
September	0.1	15.0	2.0	17.0
October		3.0	65.5	21.0
November	57.5	10.0	8.0	0.4
December			7.5	41.0

The director of the meteorological office says:

From these figures will be understood the extreme aridity of the climate contiguous to the foothills of the Andes, and that the entire agricultural richness of the Andine provinces depends directly upon the melting of the snows on the elevated peaks of the great Cordilleras. In the city, also, snow is accustomed to fall frequently during the winter, but to no great depth. And yet, owing to the extensive system of irrigation, the greatest part of the lands in the neighborhood of the rivers has been made very productive, being devoted principally to the cultivation of alfalfa, wheat, maize, and the vine.

Province of San Juan.—The province of San Juan lies to the north of that of Mendoza, and its western boundary separates it also from Chili. Its mountainous features, however, are more pronounced than those of Mendoza, the sierras there rising one behind the other in longitudinal chains which form the system of the Andes. The city of San Juan lies in latitude $31^{\circ} 32'$ and longitude $68^{\circ} 35'$, and it is 652 metres above the level of the sea. Twelve years of observations complete gives the mean monthly temperature of the city as follows:

	Degrees.		Degrees.
January	26.43	July	10.17
February	25.40	August	13.30
March	23.41	September	16.25
April	17.74	October	20.00
May	13.43	November	23.64
June	9.68	December	16.12

The mean temperature is $18^{\circ}.80$. The place is subject to very sudden change of temperature, the variation in the summer months being sometimes as great as 25° in a few hours.

I have returns complete of the rainfall for the years 1881, 1882, 1883, and 1888, as follows:

Months.	1881.	1882.	1883.	1888.
	<i>Mm.</i>	<i>Mm.</i>	<i>Mm.</i>	<i>Mm.</i>
January	35.0	3.0	39.0	40.5
February	55.0	12.0	12.0	16.0
March			1.0	8.0
April				
May		6.0	1.0	
June		4.0		
July	1.5		1.0	
August	15.5			0.2
September		7.0	6.0	
October				8.0
November	26.0			2.0
December	14.0		23.0	16.0

It will be seen from these figures that the climate is excessively dry. The clearness of the atmosphere, however, is phenomenal; and although in summer the midday heat is very severely felt, the nights are refreshed by a cool breeze from the south. The "Zonda," as the northeast wind is called, is the sirocco of South America, and prevails during the months of July, August, and September, generally beginning about 8 o'clock in the morning and continuing until sundown, during which time the heat is almost suffocating and the air is a cloud of dust. The "Zonda," however, is always followed by a south wind, which at once causes a sudden fall of the temperature and reestablishes the atmospheric equilibrium.

In reference to the climate, the director of the meteorological office says:

The quantity of water which falls is entirely inadequate to the requirements of life, and thus it is not astonishing that great tracts of country (*travesias*) are found almost entirely without vegetation, unless the required moisture is supplied by irrigation. With even a limited irrigation, however, these deserts are transformed into fertile fields, which, by the contrast, seem, as it were, like islands of paradise, where grow luxuriantly all the products of a temperate zone. The few rainstorms which occur are accompanied by violent winds and great electrical discharges, and hail frequently falls in the months of October and November, causing at times great destruction to the crops.

Province of Catamarca.—The province of Catamarca is bounded on the west by Chili and on the north by Bolivia and the province of Satta. Its superficial extent is placed at 242,309 square kilometres. Its great industry is mining, though considerable attention is also given to agriculture and the dairy. The city of Catamarca is in latitude $28^{\circ} 28'$, and longitude $65^{\circ} 55'$, and its altitude is 545 metres above the sea level. It is situated in a small valley which on the south opens into a level, arid plain. The climate is very similar to that of San Juan, very hot in summer and temperate in winter. The "Zonda" here is very frequent and sometimes blows for 48 hours, in its progress frequently parching and blasting all vegetation. Indeed, the climate is so dry that the droughts sometimes continue for 8 or 9 months of the year. Only on such spots as are moistened by irrigation is any abundant vegetation to be found. The mean temperature for each month is given as follows:

	Degrees.		Degrees.
January.....	28.27	July.....	11.78
February.....	26.60	August.....	16.03
March.....	25.18	September.....	19.53
April.....	18.77	October.....	23.70
May.....	15.40	November.....	25.76
June.....	10.72	December.....	27.64

The temperature frequently rises above 40° and scarcely ever known to fall to freezing point.

I am not able to give the rainfall, but it is much less than that of San Juan.

Province of Tucuman.—The province of Tucuman is to the southeast of Catamarca, but in climate presents a very notable contrast to it, on account of its great humidity and consequently the tropical character of the vegetation. Indeed, owing to its innumerable farms and rich vegetation it is called the "garden" of the Republic. Its superficial area is about 70,000 square kilometres, a large portion of which is relatively well cultivated. The capital city of the same name is in latitude $28^{\circ} 50'$, longitude $65^{\circ} 12'$, and its altitude is 464 metres above the sea. I have the mean monthly temperature of Tucuman for 16 years, and there is but little variation in the readings. I give that for 1885.

	Degrees.		Degrees.
January	25.0	July	11.3
February	23.1	August	15.1
March	21.0	September	19.3
April	17.4	October	20.1
May	13.6	November	24.5
June	11.9	December	24.5

The highest temperature recorded was December 25, 1862, when it went to 40°, and on three occasions it went down to 0°.

The rainfall for the years 1886, 1887, and 1888 was as follows:

Month.	1886.	1887.	1888.
	<i>Mm.</i>	<i>Mm.</i>	<i>Mm.</i>
January	307.6	323.0	85.9
February	241.2	95.1	48.7
March	201.1	119.6	211.0
April	26.5	30.3	44.4
May	8.0	5.5	12.1
June	21.1	4.9	29.2
July	0.0	31.8	4.5
August	2.3	2.0	1.5
September	5.6	14.2	65.5
October	40.5	100.4	83.6
November	93.1	97.8	168.3
December	115.2	106.0	221.4

The mean monthly rainfall by seasons for the last 15 years was as follows: Spring, 205.3; summer, 488.2; autumn, 233.6; winter, 31.1.

Province of Cordoba.—The province of Cordoba is partly pampa and partly mountainous, and exhibiting great diversity in the quality of the soil, is admirably adapted for agricultural pursuits and grazing, the only drawback being a tendency to droughts during the summer months. The city of Cordoba is situated on the banks of the Rio Primero, just on the edge of the great plain which extends to the Atlantic Ocean, the Sierras rising on the west to a height of 2,500 feet. I have the mean monthly temperature for the last 15 years, and there is a remarkable uniformity in the figures. I give the following for the year 1887:

	Degrees.		Degrees.
January	23.4	July	10.5
February	22.4	August	16.0
March	21.	September	15.5
April	16.3	October	17.7
May	12.7	November	19.7
June	12.7	December	21.6

The rainfall likewise shows a remarkable uniformity. I have the returns for the last 15 years, and the largest amount in any one year was 988.7 millimetres in 1878, and the smallest amount was 528.7 in 1887. For the years 1887 and 1888 it was as follows:

Month.	1887.	1888.
	<i>Mm.</i>	<i>Mm.</i>
January	91.4	15.3
February	47.8	68.5
March	30.4	130.1
April	68.4	.....
May	10.5	67.0
June .....	.....	2.3
July	7.0	.....
August .....	.....	.....
September	8.0	9.5
October	49.0	31.6
November	136.3	119.5
December	84.9	161.9

The mean monthly rainfall by seasons for the last 8 years was as follows: Spring, 194.3; summer, 310.6; autumn, 144.3; winter, 16.1.

I might extend these meteorological returns, but they are quite sufficient to show the character of the climate in the irrigated regions and the annual amounts of rainfall. From an examination of them it will readily be understood that without some artificial means of watering the soil there would not be moisture sufficient for the production of crops with any certainty, unless, perhaps, in Tucuman and Cordoba.

SOURCES OF THE WATER SUPPLY.

The water supply in all these provinces for the purposes of irrigation is almost exclusively from rivers, streams, springs, and small water courses coming down from the mountains. The great trouble, however, with those rivers which have their sources in the Cordilleras of the Andes is their unequal volume of water. With the melting of the snows, or during the rainy season, they are generally full to overflowing, but they soon run out, and at the very times when their waters are most needed. Indeed, with the exception of the system of rivers which flow to the Rio de la Plata, and which includes the Uruguay, the Parana, the Paraguay, the Pilcomayo, the Vermijo, and the Salado, there is not a single river in the entire republic, until we come to the rivers south of the province of Buenos Ayres, which has any outlet. Those of the central system, most of which cross the province of Cordoba, after a dreary course to the eastward, are swallowed up in the sands before they reach the Parana. Those which compose the system of the Cordilleras are all lost in quagmires and marshy lagunes before they reach the ocean. With their shallow beds running down very slight inclines, and their great evaporation from the high temperature of summer, many of them quite dry up during 4 or 5 months of the year, and these streams are all in those belts of country which have the greatest need of moisture.

CHARACTER OF THE IRRIGATION WORKS.

In regard to the character of the works used for the storage and distribution of the water, as a general thing, it may be said that they are of the most primitive kind. In most cases they consist merely in holding the waters by means of dams built at intervals along the courses of the streams, and from the higher levels thus obtained making canals or aqueducts through which the water is allowed to pass by a gradual descent as it is needed to the lands which are to be irrigated. From these canals the water is distributed by means of sluices and gateways along a system of drains, trenches, or conduits to the fields and meadows which compose the irrigation district. Where the surface is level or flat it is frequently necessary to form artificial slopes for the water to pass over. The whole of the ground is then laid in broad undulating beds the upper part of which is quite level from end to end where the supply channel is cut. All the supply furrows are fed by a main channel at right angles to the beds and somewhat above them. When the flood gates are opened the water flows into all the upper channels very regularly and evenly till it fills them to overflowing in their entire length. In the case of those streams which come down from the heights of the Andes, and course through the valleys or cañons of the Sierras, there is no difficulty in holding the water at a higher level than the lands to be irrigated, but where the sluggish rivers meander across an almost level plain there

is occasion sometimes for engineering and the taking of levels. In some instances a channel receiving the water at a higher point than that to which the river flows is dug at a less declivity than that of the bed of the stream and made to carry the water higher than the banks of the river, from which level it is allowed to descend slowly and irrigate the intervening district. In some parts of the Cuyo provinces the works which serve as reservoirs for retaining the waters are of solid masonry and large sums of money have been spent in their construction. In other provinces the works are merely wooden barriers or earth embankments, which sometimes in sudden freshets are swept away with great damage, thus leaving the people of the district, until they are repaired, without the means of irrigating their lands. I give below the various sources of the water supply.

Province of Jujuy.—The province of Jujuy, which borders on Bolivia, is irrigated at various points by the waters of the river San Francisco, which making a semicircle through the southern valleys finally empties into the Rio Vermejo. While it is the only considerable stream in the province, there are a large number of small mountain rivulets from which channels also have been dug and which greatly assist the necessities of agriculture.

Province of Salta.—Salta, on the other hand, is supplied with water for irrigating purposes from no less than three large rivers, the Juramento, the San Francisco, and the Vermejo, and by a large number of mountain streams which are throughout their length utilized for agricultural purposes.

Province of Tucuman.—Owing to the chains of mountains which run longitudinally through the western portions of Tucuman this province likewise is quite well supplied with water for irrigation purposes. On the south the streams from the heights of the Aconquija range form the river San Francisco, and on the east the river Salí, afterwards called the Dulce. These two rivers, together with an innumerable number of mountain rivulets, furnish an abundance of water for irrigation purposes, and nearly all the farms and sugar plantations are thus supplied through the means of ordinary conduits.

Province of Santiago.—In the province of Santiago del Estero the principal source of the waters for irrigating purposes is the river Juramento, afterwards called Solado, which flows along the northern and eastern borders. As far as Sepulturas the river is well banked and both sides are covered with fine farms and sugar plantations, the artificial watering which they receive from the stream producing a marvelous fertility in lands which otherwise would be perfectly barren. Beyond that point, however, it spreads out into marshes or esteros (whence the name of the province) over a country which is unfit for cultivation. Another considerable water course is the river Dulce, which, after leaving Tucuman, flows diagonally through the province, passing by the city of Santiago. In that vicinity it is well banked, and by means of a series of canals furnishes an abundance of water to the estancias and sugar farms on each side. Afterwards, turning to the southeast, it reaches the Salinas or Great Salt Desert, where no vegetation can exist. Beyond this its several channels unite again and form what is called the Saladillo. Along this stream are to be found spots or "oases in the desert," which have been redeemed by means of irrigating canals; thence coursing over a barren plain, the river finally loses itself in an immense salt swamp called Los Porongos.

Province of Catamarca.—The province of Catamarca has no large water courses, though it is crossed by several small rivers, of which

the principal are the Santa Maria, the Paelen, and the Piedra Blanca, the two last named forming the Rio del Valle, on which the city of Catamarca is located. These streams and their affluents, and indeed every gorge and valley in the province down which courses a mountain torrent, are utilized ere they are swallowed up in the sands, for the purposes of irrigation. But even then the water supply is so inadequate that there are throughout the province immense districts without water courses and without rain, which must continue to be little less than sterile deserts.

Province of Rioja.—The only river of any importance in the province of Rioja is the Vermejo, and this waters only a very small portion of its surface. This river, coming down from the eternal snows of Mount Bonetí, traverses the fruitful valley of Jaquile, is increased by the torrents which come from the Valle-Hermoso, and turning its course to the south to receive the surplus waters of the valley of Jacal, finally in latitude 32°, loses itself in the sand before reaching the lagunas of Guanacache. Throughout its course it affords excellent facilities by means of sluices for irrigation, but the volume of water is wholly insufficient to meet the requirements of the people, and during the summer months, for want of moisture, there are but few places which escape the widespread drought. Wherever there is a thread of water, however, coming down from the Sierras, it has been utilized for irrigation; and in the last few years the Government has been boring artesian wells in the hope of obtaining a better supply of water, but thus far with very little success.

Province of San Luis.—The province of San Luis is as poorly supplied with water as Rioja. The only river of any importance is the Rio Quinto, which comes down from the mountains in a series of cascades, and after a southeast course is finally lost in the pampa, in latitude 31°, in an immense salt marsh called Juncal. There are several small streams whose waters are also, by means of dams and canals, utilized for the purpose of irrigation; but the great want in this province is more water; for although in good seasons there is rainfall enough for the crops, yet this can not be depended on, and an adequate harvest is only certain in those parts where they have streams for irrigation.

Province of San Juan.—The province of San Juan is in the midst of the rivers which compose the water system of the Cordilleras. The most northwardly of these is the Colorado, which is fed by several affluents from the far western sierras. The second is the Vermejo Chico, which also is formed by several affluents in the snow-covered peaks of Copiapó, at whose foot are a series of magnificent farming districts, all watered by canals from these mountain streams. This river, afterwards turning to the south, as I have said, makes its way towards the Laguna Guanacache, but is lost before it gets there. The third and most important of the group is the river San Juan, which has its source in the summits of the Cordilleras in two affluents, and flowing to the east down the valley of Pimento cuts through the mountains, and after passing by the city of San Juan turns to the south and empties into Lake Guanacache. Formerly on the breaking up of the snows the floods which came down this river caused most destructive inundations in the vicinity of the city, and sometimes devastated leagues upon leagues of the most cultivated parts of the valley. To guard against this an immense dike has been constructed, which acts as a reservoir for holding the water during the summer months. From this reservoir have been constructed numberless distributing canals and conduits all along that beautiful valley; and the water is now so abundant that there is sufficient for steady streams along the gutters of the city.

The San Juan all along its course, however, offers marvelous facilities for irrigation. At Murallier its altitude is 800 metres, while at Lake Guanacache its altitude is only 600 metres, thus giving a fall of 200 metres in a distance of not over 40 miles in a straight line. The river, however, is wonderfully crooked, and affords water for an unlimited number of canals and conduits for fertilizing all the adjacent country. Besides this all the small streams and rivulets which find their way down from the mountains are utilized for watering the lands along which they course—indeed they are entirely absorbed for agricultural purposes.

Province of Mendoza.—The system of canals and conduits for irrigation purposes is probably more complete in Mendoza than in any other of the Cuyo provinces, and the absolute requirement of water for agricultural purposes gives to its rivers and water courses a peculiar importance. The most considerable of these is the Rio Mendoza, which is formed by two short branches in the eastern slopes of the Andes, the northern confluent descending from Mount Aconcagua under the name of Rio Las Cuevas, while the southern under the name of Rio Los Horcones receives its waters from the peaks of Tupungato. After the junction the river runs to the south through the valley between the Cordilleras and the Sierra Uspillata, and reaching the level plain near Lujan shortly afterwards doubles towards the north, in this way arriving at the Lake Guanacache, into which, like the Rio San Juan, it finally disappears. Throughout nearly its entire course it furnishes the waters for an immense amount of irrigation; while the complicated network of channels in the immediate vicinity of the city, with their elaborate ramifications, is one of the great attractions of the place. Heretofore the water brought down and through the city in open trenches was used indiscriminately also for drinking and culinary purposes; but two years ago, when the cholera visited this country, the epidemic was peculiarly malignant in that city, owing, as the analysis proved, to the bad condition of the water in the canals. Since then, all water used in the city has been brought to it in closed pipes and is separate and distinct from that employed for purposes of irrigation; and the well-known healthfulness of Mendoza has once more been assured.

IRRIGATION WORKS OF PROVINCE OF CORDOBA.

The province of Cordoba has probably greater facilities for extended works of irrigation than any other of the interior provinces, as it is crossed by not less than 5 considerable rivers, the Primero, the Segundo, the Tercero, the Cuarto, and the Quinto, all of which take their rise in different parts of the Sierras, which range on the western boundary of that province, and flow to the east and southeast towards the river Parana, but which only the last named finally reaches, all the rest losing themselves in the sands of the pampa before they get there. These rivers are all utilized for irrigating the different portions of the province, as are also a number of still smaller rivers, which, rising in the Sierras of Cordoba, have their course towards the west, until they finally also disappear in the sands.

With a view to increasing the agricultural facilities of the province and thus inducing immigration, 5 or 6 years ago, under the instruction of Dr. Juarez Colman of that province, now President of the Argentine Republic, there was initiated a series of very extended works of artificial irrigation; the several rivers which run through its territory offering peculiar advantages for the purpose. Surveys and scientific

inquiries to this end were made by corps of skillful engineers. The first of these works, under the name of the "Irrigation works of the heights of Cordoba" (*Obras de riego de los altos de Cordoba*) comprehended the distribution of the waters of the Rio Primero, which passes through the city of Cordoba. The work was commenced 2 years ago and it is just now completed, and with most satisfactory results. The entire cost was \$3,800,000. It is divided into four parts, as follows:

1. *The dike of San Roque.*—This is a reservoir for holding the water of the river. It is located in a narrow cañon with precipitous mountains on each side, at a short distance from the confluence of the rivers San Roque and Cosquin, which together form the Rio Primero. It is 51 metres in height and 37 metres from the water line. The thickness of the wall is 51 metres at the base, laid in cement; 29 metres at the water line and 5 metres at the top. Its length at the base, being from bank to bank, is 30 metres; and at the top, 135 metres. It contains 50,000 cubic metres of masonry. It holds 260,000,000 cubic metres of water, and converts the valley into a large and beautiful artificial lake. It contains two flood gates, a pipe of discharge, and contrivances for removing the accumulations of sand. Upon leaving this immense reservoir, the water flows down the channel of the river until it reaches a spot called Mal Paso, a short distance from La Colera, where a second dike has been built.

2. *The dike of Mal Paso*, which forms a reservoir for the distribution of the water.—This dike is 10 metres in height and 230 metres in length, from bank to bank, and consists of 13,000 cubic metres of masonry. From this reservoir there have been constructed two distributing canals, one of which carries the water to the table lands on the north, and the other to those on the south side of the river.

3. *Main Northern Canal.*—This canal is 25 kilometres long, and has eleven aqueducts, one of which, that of Saldan, for its extent, its solidity, and its elegance attracts general attention. The point of distribution is at a height of 37.25 metres above the threshold of the door of the National Observatory in Cordoba. The slope or declivity varies between 0.02 and 0.03 per 100 metres. It has 20 secondary canals. The amount of masonry employed in the construction is 44,000 cubic metres; the excavation of stone and earth reached to 615,000 cubic metres.

4. *Main Southern Canal.*—This canal is 37½ kilometres in length, and has 20 aqueducts. The point of distribution is in a plane even higher than that of the Northern Canal. The slope is the same. It has 89 kilometres of secondary canals. The amount of masonry employed in the constructions is 45,000 cubic metres. The earth and stone excavations amounted to 842,000 cubic metres.

The area which these colossal works will irrigate amounts to 48,000 hectares at twelve floodings per year; and double that number at six per year.

Besides these, the surveys have been completed and approved for similar works on the Rio Segundo, which will hold 350,000,000 cubic metres of water, and irrigate 60,000 hectares of land at a cost of \$4,500,000; also for works on the Rio Tercero, whose principal dike will be 42 metres high and contain 286,000 cubic metres of water, at a cost of \$3,850,000; also for works on the Rio Cualio, for which two dikes are to be constructed, each 16 metres in height, which will hold 32,600,000 cubic meters of water and irrigate 17,500 hectares of land; also for the Rio de los Sances, which at a cost of \$1,400,000 will irrigate 23,760 hectares of land.

The entire cost of the works completed and the works projected is

estimated to be not less than \$15,280,000, with a capacity to irrigate 1,209,250 hectares of land, which is equivalent to \$73 per hectare. If all these works are ever completed, the territory of Cordoba, which now in some parts, owing to the want of rain, is a desert, will take a new departure as an agricultural province.

FAILURE TO OBTAIN DETAILS.

I regret that I have not been able to be more explicit or go into greater detail in regard to the character of the works of irrigation in all the different provinces; but I have found it almost impossible to obtain any authentic information whatever. Upon the receipt of the circular of the Department I at once applied to the interior department of the Argentine Government in the hope that it could furnish me with printed reports, surveys, or statistics in regard to the more important irrigation or storage systems employed in the interior provinces, but I was informed that it had nothing of the kind at its command. I then immediately addressed letters to the governors, stating the object I had in view and asking for such data on the subject as I supposed of course they would be able to send me; but, although over a month has elapsed, I have not yet received a word from any of them, and it is hardly worth while for me to delay my report any longer in the hope of obtaining them. Under these circumstances I have had to depend solely on such outside information as I have been able to procure; and, except in the case of the works in the province of Cordoba, to speak only in a general way. In regard to the latter I have had access to a book descriptive of the province, by Señor Santiago J. Albarracin, and which devotes a few pages to the subject of irrigation. In regard to the other provinces, however, the modes of irrigation employed are generally so primitive and so simple, being in most cases mere trenches with sloping sides, that I doubt if it would be of any service, even if I could give more detailed statements in regard to them.

DISTRIBUTION OF THE WATER.

In regard to the rules or laws which govern the distribution of the water, of course it all depends upon the tenure of ownership. In many of the provinces, if not indeed in all of them, there are numerous canals cut for irrigating purposes, which are the property of the owners of the land through or over which the canals are made. The province has had nothing to do with their construction, and, of course, collects no rental or tax for the water used. Where the works have been constructed by the provincial government a tax is paid by those who make use of the water, and this varies in the different provinces according to the expense or cost of the works. I regret that only in a few cases I am able to give the rates charged for the use of public water, not having been able to procure the laws under which the irrigating canals have been constructed.

In the province of Santiago del Estero it is provided that all agricultural establishments and gardens which use the water of the public irrigating canals shall pay a tax of \$1.50 per hour; and manufacturing establishments shall pay \$2 each time they request the water, not to exceed 4 hours each time; for a single hour, 50 cents each time. Subscribers for the use of the water for irrigation have the right to six times per month during the year; and in case they do not receive this amount in the course of the year they are entitled to a proportionate rebate, but the law does not appear to state what amount of water shall be used.

In the province of Mendoza the annual tax is \$30 per square (about 5 acres), the water to be used not oftener than one day in the week, the tax to be paid quarterly. For each house situated on the canals where there is a service of water, a tax of 25 cents per month is charged. Those who make use of the water surreptitiously or who use it out of their turns must pay a fine of \$20 for each offense.

In the province of Tucuman the water of the "Western Canal" is sold for the purpose of irrigation at the rate of \$3 per mark per 24 hours, and for brickmaking at 30 cents per 1,000 bricks.

In Catamarca 6 cents per hour is charged for the use of the water from the Rio Tala, payable monthly.

In Cordoba the charge per square is \$30 per year, payable quarterly, the water to be used one day in the week. Those who use the water out of their term or without permission are liable to a fine of \$20 each time.

WATER RIGHTS BY PRESCRIPTION.

These water rates, however, it will be borne in mind, are only collected in cases where the provinces are the proprietors of the works. In many cases, as I have said, the canals are the property of the land owners on each side of the stream. It is a part of the history of the conquest, that when the Andine regions came into the possession of the Spaniards they occupied the country in the neighborhood of the rivers, in some cases driving the original inhabitants away from their settlements, and in others not only appropriating their settlements, but even reducing the Indians to the condition of slaves and requiring them to cultivate lands which were their own. These lands were held in vast estates, and with the organization of the governments it was found that all the arable places were in the possession of comparatively a few persons, who either found irrigating canals already constructed upon the lands, or who compelled the enslaved Indians to dig them. Thus all these landed estates have had from the beginning a right to the use, if not the control, of the streams along which they are located. And, as with the increase of population these estates have gradually been divided up into smaller properties and sold, a certain amount of the water for irrigating purposes has been sold with them. Thus the quantity of water which the different properties are entitled to is in most cases fixed by their title deeds.

AREAS OF LAND UNDER IRRIGATION.

In regard to the areas of land under irrigation, compared with such as are cultivated without irrigation, together with the quantity and quality of the crops grown, it is not possible to speak with exactness. As no census of the country has been taken for the last 20 years, it is usual to base all calculations on estimated figures; and that is all that can be done in this case. Fortunately I find in the message of the President of the Republic to the present Argentine Congress a table of statistics, "being the first ever attempted," giving the amount of land under cultivation in each province for the year 1888, compared with the total areas. I reproduce his figures below:

Provinces which depend on irrigation.

Provinces.	Area in cultivation.	Total area.
	<i>Hectares.</i>	<i>Hectares.</i>
Cordoba.....	234,395	17,478,700
San Luis.....	19,800	7,591,780
Mendoza.....	88,546	16,081,800
San Juan.....	79,639	9,750,500
Rioja.....	22,217	8,903,000
Catamarca.....	44,618	9,064,400
Santiago del Estero.....	120,400	10,235,500
Tucuman.....	35,943	2,419,900
Salta.....	38,525	12,826,000
Jujuy.....	18,994	4,538,600
Total.....	703,077	98,878,200

Thus, out of a total area of 98,878,200 hectares of land in these interior provinces we find that only 703,077 hectares are under cultivation, being scarcely .07 per cent of the entire area. It will readily be seen from this that it is only along the water courses that there is any irrigation, or, indeed, any vegetation at all.

The provinces which, owing to the frequency of the rains, do not require irrigation for the production of crops, are the following:

Provinces which have no irrigation.

Provinces.	Area in cultivation.	Total area.
	<i>Hectares.</i>	<i>Hectares.</i>
Buenos Ayres.....	868,868	31,123,700
Santa Fé.....	566,537	13,158,200
Entre Ríos.....	136,151	7,645,700
Corrientes.....	46,631	8,114,800
Total.....	1,637,977	59,942,400

In these four riverine provinces, out of a total area of 59,942,400 hectares of land, there are 1,637,977 hectares under cultivation, being about 2.5 per cent. of the entire area.

The President, in his message, calls attention to the difference in the percentage of land under crops in the riverine provinces and in the interior provinces, and says "it shows the relation there is between easy means of communication and the cultivation of the land." There is no doubt that the outlet the former have to the seaboard does give them some advantage, but the great advantage which they possess consists in their better climate and their more reliable supply of moisture from fertilizing rains. A large percentage of the lands in the interior provinces, owing to the limited supply of water they afford beyond the immediate banks of their water courses, must continue to be, what it now is, an unproductive area of desert, unless the deficiency can some time be made up by the sinking of artesian wells, a problem which the Argentine National Government has for some time been trying to solve, thus far, however, without any great success. Should artesian water, however, be finally reached in sufficient quantities to meet the requirements of agriculture, all the interior provinces, much of whose areas are now but waste places, would receive a new stimulus and have a more pros-

perous future in store for them. They would then be able to produce crops not only of as good quality but perhaps in as great quantities as the more favored portions of the Republic. Until then, however, the provinces of the littoral must continue to be the chief centers of Argentine agricultural industry.

E. L. BAKER,
Consul.

UNITED STATES CONSULATE,
Buenos Ayres, September 12, 1889.

BRAZIL.

REPORT BY CONSUL BURKE, OF BAHIA.

After diligent inquiry on the questions connected with irrigation, as set forth in circular of May 2 last, I have the honor to say, from information received from different parties, I have ascertained that irrigation in this consular district is carried on solely by nature; that man has not yet interfered in any way with nature either for promoting irrigation and the "reclamation thereby of arid lands" or in attempting to prohibit nature from taking its course. The sugar, the cacao, and the coffee plantations are mostly on the banks of large streams or rivers, where of course the soil has a greater degree of moisture than on the uplands in the dry season, and where they catch the overflow whenever the rivers or streams are swollen by heavy showers or long-continued rain. I have heard of no steps being taken towards devising any system of irrigation.

DAVID N. BURKE,
Consul.

UNITED STATES CONSULATE,
Bahia, October 7, 1889.

PARA.

REPORT BY CONSUL CLAYTON.

I beg leave to acknowledge receipt of the Department's circular of May 2, calling for a report on irrigation and the reclamation of arid lands, and in reply beg to state that as Para is well situated in the rain belt of the tropics, irrigation is not required, and therefore works of such a nature are unknown here.

ROBT. T. CLAYTON,
Consul.

UNITED STATES CONSULATE.
Para, July 20, 1889.

BRITISH GUIANA.

REPORT BY CONSUL WALTHALL.

No systematic irrigation exists in this colony. The need of it is felt when the dry seasons are protracted beyond their ordinary limits, but in such cases the only methods employed to water the crops are of the simplest and most primitive description, by manual labor, without the aid of machinery of any sort. The system of drainage, however, and of the employment of artificial water ways for the transportation of produce and plantation supplies is elaborate, costly, and extensive. Although not strictly pertinent to the information sought by the Department, the subject is somewhat akin, and a brief account of it may not be irrelevant.

In order to understand the conditions it must be borne in mind that the rich agricultural region of the colony consists in general of the lowlands adjacent to the seacoast and the tidal parts of the larger rivers. These lands are several feet below the level of the highest tides, for which reason it is necessary to protect them from overflow by a continuous line of embankments, or "sea dams," as they are termed.

This cultivable region extends back from the beach and the banks of the lower rivers to a distance varying (by a rough estimate) from 2 to 5 or 6 miles, when it meets what is termed in the language of the colony, perhaps very correctly, "the savanna," or "bush" lands. This is a belt of country between the rich coast lands and the hills and forests of the interior, slightly more elevated than the former, but lower than the latter, partly open and partly covered with trees, vines, and shrubs, but everywhere abounding in swamps, ponds, and creeks of fresh water.

These estates of the colony are laid off on the plan adopted by the original Dutch settlers, and still existing in its main features. They are divided by parallel lines, approximately perpendicular to the line of waste, and forming long, narrow, and somewhat irregular quadrilaterals, which would be parallelograms but for the sinuosities and irregularities of the coast line. The unit of measurement of distance is the Rhymland rood, still in habitual use, of 12 feet 4 inches. The original width of each grant was 100 roods, or nearly a quarter of a mile, and the length, or depth from the sea dam, 750 roods, or about $1\frac{1}{2}$ miles. Such is at this time actually the extent inland of the only lands owned in fee simple, though many of the estates have been extended toward the "savanna," or including parts of it, by grants of possession and occupancy at the pleasure of the Crown, supposed to be practically equivalent to ownership. Many of the original estates have also been united, and some of them divided, though the regular parallelism of their side boundaries is still maintained.

In order to protect these estates from overflow in the rainy seasons by the waters of the swamps, ponds, and streams of the "Savanna," back dams are erected in the rear of the cultivated area. On the lines of division between the estates canals or trenches are dug for drainage, the earth thrown out from these constituting material for embankment, known as "side-line dams," which also serve as roadbeds for walking or riding. Smaller cross drains connect with these side-line trenches.

Besides the trenches for drainage another system of trenches or canals is employed for the internal navigation of the estate. For this purpose a canal is generally dug through the estate, the excavated earth forming alongside of it an embankment known as the "middle walk," transversely from this toward the boundaries of the estate but stopping short

of them, so as not to communicate with the side line for drainage trenches—the terminus of the navigation cross canal forming a sort of “cul-de-sac.” These canals are used for the transportation by flat-bottomed barges or “punts,” of the crops, fertilizers, etc., in one direction or the other.

These canals are supplied with fresh water from the swamps, creeks, ponds, and in some cases artificial reservoirs of the “Savanna,” the water being admitted and the supply regulated by means of water gates, or “kokers,” as they are termed, in the back dams.

Stronger and more elaborate kokers are employed in the sea dams, which are opened at low tide to permit the discharge of the drainage and other fresh water, and closed at high tide to hinder the influx of the sea water.

The coast lands of the colony consist of a stiff clay, interspersed with veins of sand, and covered with a superficial layer of vegetable mold, or “pigass.” The clay being impervious to the percolation of water is very favorable to rapid drainage from the surface.

The chief staple is sugar, though there are some cocoanut plantations, and in certain parts of the colony large estates, or cattle farms, are devoted to pasturage.

I have spoken of artificial reservoirs. The advantages of these in regulating the varying supply of fresh water during the wet and the dry seasons are obvious. Besides those already existing, others are projected on a still larger scale.

The cost of the works required for drainage and the supply of water to the towns, villages, and estates, is assessed on the proprietors and others interested, though they are controlled and regulated by the government. The money is frequently advanced by the government, with the understanding that it is to be repaid by taxes on the property for the benefit of which it is expended. This, of course, does not apply to the works undertaken by proprietors for the special benefit of individual estates. In some cases, also, participation in the burdens and benefits of public or corporate enterprises is to some extent optional with the individuals interested.

The climate of the colony is torrid, but remarkably uniform, the extremes of temperature being about 73° and 90° Fahrenheit. The average is about 81°. The annual rainfall is estimated at about 100 inches.

W. T. WALTHALL,
Consul.

UNITED STATES CONSULATE,
Demerara, August 2, 1889.

CORRECTING THE FOREGOING REPORT.

In his report on canals dated November 8, 1889, Consul Walthall corrects the foregoing report as follows:

This report, covering ground closely related to that of the 2d of August last on “Irrigation and Drainage,” must be taken in connection therewith, as supplementing or explaining some of its statements, and also as affording an opportunity for the correction of a few minor inaccuracies.

The first sentence of the report referred to may have been liable to misconception. In saying that “no systematic irrigation exists in this colony,” the term “irrigation” was employed in the restricted sense in which it is popularly used, to signify the direct application of water to crops under cultivation for the purpose of promoting their growth. In its larger sense, of the introduction of water for drinking, washing,

and other uses of man or beast, and in this colony more especially for the transportation of crops when gathered, that report itself may have shown how extensively it is employed.

Again, opportunities since enjoyed for personal observation have shown me the mistake of confounding the terms "bush" and "savanna," as employed in this colony. They are not at all interchangeable. The former is applied only to wooded ground, forest or thicket, dry or swampy; the latter only to open marsh or dry prairie, the vast "savannas" immediately in rear of the cultivated plantations being covered with water during the rainy season, without trees, while the open spaces of dry ground, farther inland, to which the same term is applied, are interspersed with occasional clumps or strips of trees or copse wood.

The plan of a Demerara sugar estate, herewith inclosed, should more properly have accompanied the previous report, but had not then been obtained. It has been drawn by an experienced land surveyor, not as an exact representation of any particular estate, but as a model, showing the principals on which they are usually laid out. It requires little explanation beyond what has already been given in the previous report and those furnished on the face of the map itself or by the notes and references in the margin.

It will be observed in this plan that the main navigation trench, or canal, is double, consisting, in fact, of two canals, *i, i*, with a middle walk, *n*, between. This is the approved and better usage, though in many estates economy is consulted by having only a single canal on one side of the middle walk. In that case the cross canals, or punt trenches, *k, k*, on one side of the plantation, necessarily pass through or under the middle walk, which is bridged where where they cross it. These navigation canals or trenches are supposed to have a depth of about 5 feet.

The plan shows the ingenious system by which the navigation and draining trenches both permeate the whole plantation without communicating with each other, the transverse trenches of each system communicating, the one with the main navigation canal, *i*, the others with the side line drains, *h, h*. The punt trenches, *k, k*, divide the cane fields; the main drains, *o, o*, bisect them longitudinally, or transversely to the configuration of the whole estate. In one of the fields the draughtsman shows the manner in which the beds of cane, *m, m*, are laid off, divided by minor drains, *p, p*, leading on each side into the main drain, *o*.

On the right is shown, also, an occasional, though not invariable, feature in the topography of the colony. This is the company dam, or company path, *A*, which occupies a strip between two estates, reserved by the town for the use of the public, or more especially of the proprietors of the adjoining lands, in common.

REPUBLIC OF COLOMBIA.

PANAMA.

REPORT BY CONSUL-GENERAL ADAMSON.

There is no artificial irrigation of lands in the district of this consulate-general.

All the lands are abundantly watered by the rains, which are frequent during the greater part of the year.

Here there is no system of cultivating lands that could with any propriety be dignified by the name of agriculture, and therefore there are no crops to speak of.

Probably not more than 1 acre of each 10,000 acres in the department of Panama is under cultivation, and that only with maize, yucca, and other food crops.

There would be no profit in producing surplus crops which could not be marketed, and there are no roads for wheeled vehicles in this department excepting in the near suburbs of Panama.

THOMAS ADAMSON,
Consul-General.

UNITED STATES CONSULATE-GENERAL,
Panama, July 12, 1889.

CHILE.

COQUIMBO.

REPORT BY CONSUL GRIERSON.

AREA IRRIGATED.

This province is in a very backward and primitive state as regards cultivation and irrigation on account of the country being very barren and mountainous, the only cultivation being along the valleys running down between the mountains, which convey the snow water from the Cordilleras. Hay and barley are the principal productions, the former when green being eaten on the ground by cattle.

WATER SUPPLY.

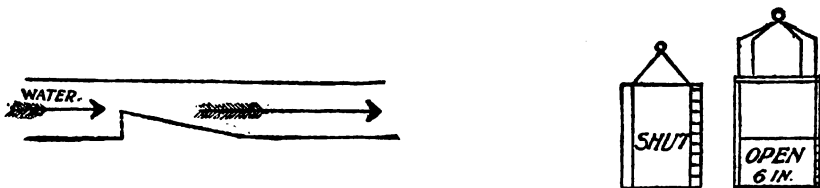
Water is supplied by canals or large ditches cut at different places from the rivers of snow water as mentioned above. Each canal from its leaving the river until it reaches the sea belongs to the owners of land along the upper part of which the canal flows.

MODES OF IRRIGATION.

No works are made for storage of water. When the river is full the sluice doors to the canals are open all the time, and water is supplied in abundance all the time, but in years when there is little snow on the mountains, and consequently the river low, the sluices are opened as arranged by the canal committee.

WATER DISTRIBUTION.

Each canal has a president and committee elected from the owners, who superintend repairs, allowance of water, etc. The value of a farm depends on the number of inches belonging to it. Each proprietor of land can buy or sell any or all the number of inches of sluice he has a right to draw from the canal; each inch being worth about \$3,000, American gold, and is the same as tangible property.



Sluice-wall 15 to 20 inches makes a good farm worth about \$3,000 to \$4,000 American gold yearly.

CLIMATE, RAINFALL, ETC.

The climate is good and very mild up the valleys. Grapes, oranges, pears, grow well, and by irrigation five crops of hay may be cut yearly. From 1872 to 1880 our rainfall was only $3\frac{1}{4}$ inches per year. Latterly, with intermissions, it has been about 7 inches yearly.

ANTIQUITY OF IRRIGATION.

The rivers are, of course, under Government, but the canals are private property, and from time immemorial have been superintended and kept in order by their owners. Every town, however, is entitled to a proper proportion of water.

J. GRIERSON,
Consul.

UNITED STATES CONSULATE,
Cochimbo, September 1, 1889.

ECUADOR.

REPORT BY CONSUL-GENERAL M'GARR, OF GUAYAQUIL.

AREA IRRIGATED.

A very small quantity of land is under irrigation in Ecuador—not the thousandth part of the cultivable land. No grain crops are grown on irrigated land, which is used only for pasturage and for raising alfalfa in small quantities. An infinitesimal part of the arid region, which is extensive in northern Ecuador, is under irrigation.

WATER SUPPLY.

Small rivers, mountain streams, and springs are the sources of the water supply. There are no basins, reservoirs, or tanks used.

MODE OF IRRIGATION.

There are no works constructed for the storage of water. Its distribution is by ditches. No reports on the subject have been published in this country.

WATER DISTRIBUTION.

The system of water distribution is governed by custom, except in the few instances where water is carried over the land of adjoining proprietors. In such cases the law regulates and defines the rights and duties of the owner of the easement and of the servient estate. I have no means of ascertaining the amount of *water* used per acre or per season. It is not measured and it is not rented. The water used for purposes of irrigation belongs to the individual land owner using it. There is no national, municipal, or community ownership.

CLIMATE.

The climate is that of the interandean region, with an average maximum temperature in the shade of 62° to 68°, the average minimum being about 54°. In some localities the soil is a sandy loam, and in others a dark, heavy clay and very deep. The rains are ordinarily confined to the months between the middle of December and the first of June, and are quite copious in most seasons. I can not state the annual rainfall.

ANTIQUITY OF IRRIGATION.

Under the Spanish rule there was something of an irrigation system, regulated by laws, and at the time of the conquest there was a better and more extensive system than has existed since. That now in use is maintained entirely at private expense.

OWEN MCGARR,
Consul-General.

UNITED STATES CONSULATE-GENERAL,
Guayaquil, August 21, 1889.

DUTCH GUIANA.

REPORT BY CONSUL BROWNE, OF PARAMARIBO.

In this colony irrigation is not necessary, owing to the heavy rain-falls, which continue for at least 6 months of the year.

The quantity of rainfall for the year 1888 has been 2,276 millimetres, equal to 87.5 inches, and the average annual rainfall for the previous 10 years was 2,214 millimetres, equal to 87 inches.

THOMAS BROWNE,
Consul.

UNITED STATES CONSULATE,
Paramaribo, September 4, 1889.

VENEZUELA.

REPORT BY CONSUL BIRD, OF LA GUAYRA.

The subject of irrigation, to which the attention of consular officers is directed by circular instruction from the Department of State dated May 2, 1889, is one upon which very meager information can be furnished from Venezuela; for although in a crude way irrigation is practiced to some extent, yet there are no available statistics to offer in reference to the areas of land under irrigation and no means of comparing these with the nonirrigable and cultivable lands. Of the small area of cultivated lands in this consular district, exclusive of those planted in coffee, perhaps the greatest part is devoted to sugar cane; and, from personal observation, it would appear that the crop generally needs more cultivation and irrigation than is usually given it.

The small streams coming down from the mountains form the only supply of water for the purposes of irrigation, and, in a tropical climate like this, the volume of water is so often reduced during the long and hot summer season that the supply proves inadequate, and consequently the crops suffer to a greater or less extent. The present season has proved quite disastrous in this respect, so much so that crude sugar, usually sold at 10 cents per pound, is now worth 25 cents per pound. The importation of cane products being prohibited by law, it seems that the use of sugar and its compounds, so general in this climate, must be greatly curtailed and, to many of the poorer classes, entirely cut off.

The character of the works used for the storage and distribution of

water are of the simplest description and consist of ordinary dams and trenches. There are no irrigation and storage works of any importance, every process of this nature being conducted upon the most inexpensive and antiquated plan. It is no doubt true that even the Chinese are in this respect far in advance of these people in the various appliances and processes for irrigation, and it is equally true that if a more careful and provident system were adopted much of the water that now goes to waste might be utilized for the reclamation of arid unproductive lands.

The system of water distribution is governed, according to the best obtainable information, by custom only, although there are some statutes in reference to it that, by common consent, have fallen into disuse. The unwritten law is that each person shall have the right to water on a stated day for a certain length of time, when he must close his flood gate and again await his turn. Under such an arrangement, therefore, it is evident that the amount of water used per acre and per season and the tenure of ownership, etc., can not be intelligently stated.

Everything connected with the subject of irrigation in Venezuela is of such primitive character that it can be of no special interest in the elucidation of plans and processes for use in the United States. No maps nor publications with any reference to it can be obtained or even heard of; and it appears that the subject has never received the slightest degree of the attention that its importance to the agricultural interests of the country seriously demands.

WINFIELD S. BIRD,
Consul.

UNITED STATES CONSULATE,
La Guayra, October 8, 1889.

NICARAGUA.

REPORT BY CONSUL WILLS, OF MANAGUA.

Referring to your inquiries contained in a communication from the Department of State, dated Washington, May 2, 1889, requesting a report on the subject of irrigation as practiced in Nicaragua, I have to inform you that there is not, nor has ever been, as far as I can learn, any system whatever of irrigation.

Near Nandaime, a small Indian town in the department of Rivas, three cacao (chocolate) estates are partially flooded in a primitive way by their owners from small rivers or streams being dammed to cause the water to flow over the plantations, which are below the streams. No system is practiced.

CHAS. H. WILLS,
Consul.

UNITED STATES CONSULATE,
Managua, August 16, 1889.

SALVADOR.

REPORT BY CONSUL TUNSTALL, OF SAN SALVADOR.

There is no system of irrigation in practice in this consular district or in the Republic of Salvador.

Here, where we have a rainfall once and frequently twice in the 24 hours, from about the 1st of November none is needed. Then the dry or summer season, as it is designated here, sets in and continues till the last of May or 1st of June, during which time the intense dew falls suffice for rain showers and supply all vegetation with the necessary amount of moisture for the crops grown in the meantime. Hence there is no necessity for a system of irrigation.

T. T. TUNSTALL,
Consul.

UNITED STATES CONSULATE,
San Salvador, July 21, 1889.

CUBA.

SANTIAGO DE CUBA.

REPORT BY CONSUL REIMER.

Before answering the questions propounded in circular of May 2, it would be well to enumerate in brief the reasons which render artificial irrigation in this consular district almost unnecessary. I say "almost unnecessary" because all the crops, such as sugar, cacao, coffee, plantains, and other crops of minor importance, are dependent on the changes of rainy and dry seasons in this tropical climate.

This consular district is well watered by rivers and small streams, which irrigate the rich and deep alluvial soil under cultivation. The largest river, the Cauto, finds its source in the Sierra del Cobre mountain range to the westward of this city, and after a tortuous and winding course, during which it receives various tributaries, empties into the sea 14 miles north of the town of Manzanillo. This river, choked up at its mouth by driftwood and sandbars, is about 180 miles long, of which 60 are navigable. Captain-General Salamanca has caused studies to be made with a view of forming a plan to make the mouth of the river navigable, thus opening a water course which traverses some of the most fertile districts of this province. The Cauto, with its tributaries, constitutes the water system of the south coast of this province.

Between the capes Maisi and Cruz the coast line is very mountainous and only small streams find their way to the sea. The north coast is full of larger and smaller rivers, which find their way into the numerous and large bays, notably the Mayari, Naranjo, etc., so artificial irrigation has as yet not become a necessity excepting, to my knowledge, only in one instance. Bussers, Brooks & Co., an English firm, here owning a sugar estate on the Bay of Guantanamo and called "Los Cañitos," have been compelled, owing to the curious fact that although sufficient rain falls near and around the estate, very little falls on its territory, to introduce an artificial system of irrigation. This system of open ditches irrigates about 10 *caballerias* (333½ acres) of cane fields, and as it is just commenced I can not give you the results.

The water for this system is procured from the Guantanamo River, which is dammed above the area irrigated and the water distributed by a system of canals. The system was instituted after the necessary permission was obtained from the Spanish Government, is a private enterprise, and pays neither rental nor taxes. The amount of water used per acre depends on the rainfalls of the rainy season, and can not be estimated, as the work has just commenced. The character of the climate is tropical, and the annual rainfall, in the absence of all scientific observations, I would estimate at 45 inches.

OTTO E. REIMER,
Consul.

UNITED STATES CONSULATE,
Santiago de Ouba, August 7, 1889.

MEXICO.

REPORT BY CONSUL-GENERAL MORE.

INTRODUCTION.

The system of irrigation has become very generally practiced in various portions of this Republic, having been in vogue, more or less, ever since the days of the conquest of the country by the Spaniards, in 1521.

It may be stated, as a general proposition, that the natural supply of water in Mexico is very limited, as compared with that of other countries. The traveler in this Republic notices the great scarcity of rivers, running streams, lakes, and springs. In the mountains of the country many small streams take their rise, but soon after reaching the plains they become absorbed in the sandy soil and sink into the ground. Again, in Mexico during the rainy season there is a great abundance of water (said rainy season may be stated, in a general way, as extending from June 1 to the 1st of October) but for the remainder of the year the rainfall is very scant; water becomes very scarce and the whole country becomes very dry, except in the regions along the seaboard (the Pacific Ocean, the Gulf of California, the Gulf of Mexico, etc.), in which localities the dews are very heavy and refreshing showers much more frequent than in the upland regions.

I will now take up the six points of interrogatory mentioned in your circular, and incorporate in my replies the information obtained from the Department of Public Works and from other sources.

AREA IRRIGATED.

There are no statistics upon which to estimate the area of the land irrigated. The principal crops grown here with the assistance of irrigation are sugar, coffee, corn, wheat, oats, barley, beans, cotton, and tobacco; also, oranges, bananas, and other fruits. Without irrigation, except near the coast, the yield would be very meager; with irrigation said crops are excellent, and will compare favorably with those of other countries, especially when consideration is had of the primitive agricultural implements used and the inefficient cultivation as contrasted with that practiced in the United States, England, France, and Germany.

WATER SUPPLY.

The water supply for irrigating purposes is drawn principally from rivers, streams, and natural lakes. In some instances bold springs gush from the earth and furnish a constant, never-varying supply for the irrigation of thousands of acres, as in the case of "Atlacomulco," in the State of Morelos, a large, beautiful hacienda or plantation, at one time owned and operated by Cortez, the Spanish conqueror, and still belonging to his descendants, or the hacienda of "Coahuistla," one of the finest sugar plantations in Mexico, near the city of Cautla. Sometimes also large dams of solid masonry are constructed, at great expense, which, however, form large reservoirs of water during the rainy season, and which during the remainder of the year furnish the necessary supply for irrigation. Artesian wells supply some of the water used for irrigation; also wells from which the water is raised and poured into the irrigating canals by means of windmill pumps, and buckets attached to "endless chains" which are kept in motion by mule or horse power.

MODES OF IRRIGATION.

The works used for storage and distribution of water consist of dams, constructed so as to elevate the level of the water in streams and rivers, where they can not be tapped by the aqueducts and irrigation canals at sufficient elevation to reach the destined fields of cultivation; also large reservoirs are formed, as above stated, through the instrumentality of massive dams, generally of stone masonry, the water being collected during the rainy season and held for use when needed.

WATER DISTRIBUTION.

As a part answer to the fourth interrogatory, the department of public works handed me a copy of the decree of June 5, 1888, which I herewith have the honor to inclose, accompanied by a translation of the same into English.

Each State of the Republic has its separate laws and regulations regarding the distribution of water. The duty of water per acre and the amount used per season per acre, vary according to the quality of the soil, climate, and plants under cultivation. Moreover, the cost of water is generally included in the rental paid for the lands, which varies exceedingly in different places, according to the peculiar circumstances attending each locality.

The ownership of the water is both public and private, but generally the latter, as the water privileges, being considered of quite as much value as the land itself, have, in many instances, been transferred or transmitted by inheritance along with the title to the land.

DEPARTMENT OF PUBLIC WORKS, COLONIZATION,
INDUSTRY, AND COMMERCE, THIRD SECTION.

The President of the Republic has thought fit to direct to me the following decree: Porfirio Diaz, constitutional President of the United States of Mexico, to its inhabitants makes known: That the Congress of the Union has decreed the following:

ARTICLE 1. There shall be considered as general public highways, besides the inland roads, railways, etc., to the effects of section 22, article 72 of the constitution, the following:

The territorial seas, marshes, and lagoons situated on the seacoast; canals constructed by the Government or by means of public money; interior lakes and rivers, if navigable; whatsoever lakes and rivers situated and serving as boundary lines between the Republic and foreign nation or between two States.

ARTICLE 2. The Federal executive has the power and right to look after the aforementioned general public roadways and to regulate the private and public use thereof, according to the following basis:

(1) The towns situated on the sea shore or banks of a river shall have the gratuitous use of the water necessary for all domestic purposes of its inhabitants.

(2) There shall be respected and confirmed the rights of private individuals relating to the use and profit of rivers, lakes, and canals, providing that said rights consist in lawful titles or civil prescription exceeding ten years.

(3) The concession or attestation of rights or titles to private parties on the lakes, rivers, and canals relating to the present law can only be made by the department of public works, excepting the case when said concession shall change or threaten to change the course of the rivers or canals aforementioned or should deprive of the use of their waters the inhabitants living down the stream.

(4) The rights of fishing and pearl diving on the territorial seas and the uses and profits of marshes and lagoons situated on the sea shore or national vacant lands shall be regulated specially by the executive power.

ARTICLE 3. All transgressions of law comprised in the common jurisdiction committed on interior lakes, canals, or rivers, as well as the controversies that may arise between private individuals relative to obeying the statutes issued by the department of public works, shall be submitted to the competent local jurisdiction.

MIGUEL CASTELLANOS SANCHEZ,

Senator President.

LUIS C. CARIEL, *Deputy President.*

GUILLERMO DE LANDA Y ESCANDON,

Senator Secretary.

A. RIBA Y ECHEVERRIA, *Deputy Secretary.*

MEXICO, May 28, 1888.

Therefore, I order it shall be printed, published, and circulated, and that due compliance shall be given it.

Signed in the palace of the executive power of the Union, in the city of Mexico, on this 5th day of June, 1888.

PORFIRIO DIAZ.

Gen. CARLOS PACHECO,

*Secretary of State and the Department of Public Works,
Colonization, Industry, and Commerce.*

I communicate it to you for your knowledge and corresponding effects.

[Liberty and constitution.]

MEXICO, June 5, 1888.

PACHECO.

Climate, soil, etc.

The climate of the irrigated region in this country corresponds to the climate of the different States of the Republic, as in all of them there exist irrigated lands, with this general statement, however, that on and near the seacoast the climate is much warmer and the rainfall much greater than on the table land and in the mountain districts.

The nature of the soil embraces every variety known to the country, from the light, sandy soil of the table lands to the rich, dark alluvial of the valleys and the fertile black loam of "the tierras calientes," the "hot countries."

ANTIQUITY OF IRRIGATION.

The antiquity of the various systems of irrigation in Mexico varies with the different localities, they having been constructed and put into operation not simultaneously, but at different epochs, as the different sections became more or less cultivated by intelligent labor and the necessity of irrigation became apparent. As a general proposition, however, it may be stated that the said systems date all the way from

the early part of the sixteenth century, when the Spaniards took possession of the country, introducing their splendid system of irrigation as rapidly as they began the cultivation of the various localities.

The department of public works further assures me that none of said irrigation works are maintained by public funds.

C. C. MORE,
Consul-General.

UNITED STATES CONSULATE-GENERAL,
Mexico City, August 31, 1889.

COAHUILA.

REPORT BY CONSUL WOESSNER.

Your circular of May 2, 1889, directed to me, relating to irrigation, leads me to contribute a few points of interest for all manufacturers of iron tubes and well-boring implements in the United States.

A part of this section of this large and rich State is irrigated from springs, which generally rise in the mountains. The water is carried in many cases and often many miles from these springs to level, fertile land by means of narrow ditches. In other parts of this State the lands can not now be irrigated on account of no water and the total absence of the necessary implements for boring and the proper practical labor to accomplish the required result. When there are springs the water should be carried through iron tubes. Further away from here, where there are no springs, but haciendas of importance, the artesian well, it seems to me, is what is needed.

I would advise manufacturers in the United States who desire to build up a trade of this kind to do so with a direct representative who speaks the language, establishing an office centrally located in the Republic, where attention may be given to the wants and demands of such a trade.

Water is worth a great deal more than land in this country, and the right to use it is fixed by laws. A great deal of good land is not used because of lack of water, and to depend on rain in some parts is too much of a risk. With a good water supply much of the rich soil of this State would produce abundantly of nearly all kinds of products, which at present are not enough to support the population.

There are very few windmills used at present in this State, though I think they might be successfully used, for the reason that good winds blow nearly all the year. There is considerable water power unused, which according to law can be acquired by denouncement. If a spring of water rises in the property of any one, the owner of the property also owns the spring. Rivers are owned and controlled by the State through which they pass. Rights and privileges to public waters are sold by the State. The system of water distribution is as follows, and is generally acquired by purchase:

A stream of permanent water is called thirty days of water, and the owners may sell the right to any one to use this water for any length of time, say, for example, one day in every month, which is called one day of water, worth very often as high as \$1,000 per day. It is an understood right between all landowners that parties owning any right or privilege in the water can pass same to their lands through the lands of adjacent owners by means of narrow ditches.

This system often causes many difficulties, particularly when the owner of a day or two of water dies and leaves some fifteen or twenty heirs, each of whom receives his share in hours, being an equal division under the same right of the day or two of water inherited. The formation of artificial lakes has already awakened attention, and a foreign company of capitalists agitates at present the question of making a lake with the waters of the Rio Grande, to be used for industrial and agricultural purposes. This project, however, involves difficulties arising from its international character.

JOHN WOESSNER,
Consul.

UNITED STATES CONSULATE,
Saltillo, Mexico, July 13, 1889.

LOWER CALIFORNIA.

REPORT BY CONSUL VIOSCA.

The topography of Lower California is an exceptional mite perhaps from the rest of the earth composing the world we inhabit. A narrow strip of mountains, rocky and precipitous land, divested in its greater part of vegetation and water, comparatively worthless for cultivation, with exception of a few valleys. The creation of the said valleys have beyond doubt been the consequences of centuries of washed and decayed granite with other stony substances swept down from the mountains by heavy rains and wind into the gulf border, close by their proximity. The few valleys now under cultivation find their location near the sea or gulf water's edge. The component of its soil is principally alluvial, mixed with lime and granite gravel. That is in substance the natural and material state of the lands in this peninsula, lest the subject of mineralogy should be introduced, as being the most promising and important branch of its future prosperity.

The towns and localities supported by agriculture are in this country unprovided with any information relative to the land surveys, nor have they any maps bearing upon the subject of anything which might give an idea of the amount of land under irrigation. Being, therefore, beyond possibility to make an estimate of the number of areas now in cultivation and of the quantity of the nonirrigable and cultivable land existing, no regular surveys have ever been made of this country, either at large or sectional districts; and the few surveys made in granting possession of individual land grants are very imperfect; but, nevertheless, the nonirrigable lands in this peninsula far exceed those cultivated. As a matter of example, there is a certain tract of land in the shape of an extensive valley, originating in this city and extending as far as the Pacific Ocean over 120 miles in length and 40 wide, improperly reputed arid, because it is unprovided with surface water; but its soil has no rival in quality, being thickly wooded with mesquite (*accacia*), palo blanco (very productive), and manto; this last is of great use for firewood. A fair supply of rain in summer changes the face of the entire place, transforming it into one of the finest grazing spots in this country. The recent discovery made in boring for well water at a farm located on said valley of a subterranean stream, running at the depth of 70 feet from the surface, of fine, pure, fresh water, leads the people of this district to the belief that artesian-well boring could be made successful.

The crops raised out of the lands under cultivation are hardly sufficient in providing for the local consumption of sugar, panocha, corn, and beans, the gulf border States have to provide here for the deficiency almost yearly.

Water supply to the cultivated lands is from mountain streams and also several springs of permanent duration, by law still under the old régime. This country's system of water distribution among planters is regulated through the municipal town council and is allowed free of taxation, thus being governed by the old rules and regulations of the laws of Spain, the Mexican Government has not yet enacted laws regulating the using of water.

Sooner or later it will be discovered that a great deal of the land in this territory, at present considered barren and almost useless, is and can be made subject to cultivation by the use of modern appliances and improvements for irrigation and their future development, besides being, as they are just now, of great utility for sheep and cattle breeding, and as for the benefit of mankind, it has the great inducement of having a delicious and healthy climate.

JAS. VIOSCA,
Consul.

UNITED STATES CONSULATE,
La Paz, Mexico, September 20, 1889.

SONORA.

REPORT BY CONSUL WILLARD, OF GUAYMAS.

Up to the present time the lands cultivated in Sonora (this consular district) are confined to the bottom or valley lands on the small streams and rivers.

For the purpose of irrigating said lands, dams of simple construction of stone and earth, or brush and earth, are erected on the sides or in the streams, and ditches are dug to convey the water to the lands cultivated. These dams, as a rule, require repairs and some reconstruction each year.

The ditches require cleaning and repairing yearly, but are not expensive to maintain.

A. WILLARD.

UNITED STATES CONSULATE,
Guaymas, Mexico, August 14, 1889.

CONTINENT OF ASIA.

ASIATIC TURKEY.

ASIA MINOR.

SMYRNA.

REPORT BY CONSUL EMMET.

AREA IRRIGATED.

There is no irrigation practiced in this or any other district of Asia Minor, except in kitchen and fruit gardens in the neighborhood of large towns.

Water supply.—In these cases the supply of water is from wells on the premises and the machinery used is a large wheel bucket pump, worked by a horse. These wells are of various depths and the supply of water utterly fails in some, during long-continued droughts.

Modes of irrigating.—No waterworks or artificial lakes are to be found anywhere, although there are numerous rivers, streams, and lakes which could be adapted to overcome the effects of the dry season, which usually lasts from five to six months.

Water distribution.—These water sources belong mainly to the Government, in some instances to religious communities (mosques), but the right to use the same can be obtained at moderate cost.

Crops.—In this section the yield of crops depends on a merciful Providence in withholding rains during the growing and thrashing seasons; the ingenuity or industry of mankind takes but an insignificant part in producing large crops.

Tithes.—Although the largest revenue to the Government is derived from tithes on agricultural products, the overtaxed peasantry labor under great difficulties and receive no encouragement or assistance from the Government.

Rainfall and soil.—The amount of rainfall rarely exceeds 26 inches per square foot; in fact that is considered an ample supply.

The soil is mainly a sandy loam.

W. C. EMMET,
Consul.

UNITED STATES CONSULATE,
Smyrna, August 2, 1889.

SIVAS.

REPORT BY CONSUL JEWETT.

In reply to your circular of May 2, 1889 (only received by last post), asking for a report on irrigation as practiced in this country, I have to say that there is no special system of irrigation used in this part of Asia Minor, the character of the soil and the amount of rainfall making it unnecessary. Occasionally a farmer conducts a brook through his field, but the practice is limited and unimportant in extent.

In the valley of the Euphrates, and in some parts of southern Asia Minor, there are systems of irrigation, but I am unable to procure any details as to its character or extent, or the methods used.

H. M. JEWETT,
Consul.

UNITED STATES CONSULATE,
Sivas, Turkey, July 23, 1889.

PALESTINE.

REPORT BY CONSUL GILLMAN, OF JERUSALEM.

With the exception of Jaffa and its immediate neighborhood, there is no part of this consular district in which any extension and systematic attempt at irrigation according to modern methods is made.

THE JORDAN VALLEY.

In the valley of the Jordan, which contains from 500 to 600 square miles of some of the richest land in the world, and which is never visited by frosts, being from 700 to 1,300 feet below the level of the Mediterranean Sea, and where, with its semitropical climate and facilities for irrigation, several successive crops may be produced annually, only the most feeble and primitive methods of conducting the necessary water to the few and ill-cultivated fields are followed. This unique valley, capable, with proper agricultural treatment, of sustaining an immense population, has no settlement worthy of the name. The wild Bedonin Arabs range throughout its length and breadth, and in defiance of the Turkish Government, which have in vain attempted to drive them out, come and go at their own free will.

Small fields, gardens, or patches, of ground are here and there cultivated in the neighborhood of some stream having its source in one of the perennial springs of the region. From such a spring the water is conveyed in shallow drains or ditches to wherever required, and is carried through the fields or gardens by still smaller channels, the water being shut off or let on simply by the action of the foot, opening the tray inlet, or blocking it up with a few pebbles or masses of clay, as may be desired. This is a habit as old as the oldest writings, and of which mention is made in the Bible: "Where thou sowest thy seed, and wateredst it with thy foot, as a garden of herbs." (Deut., XI, 10.)

Only the common farm crops are cultivated, but they are of specially exuberant growth. At Nablons or ancient Shechem or Sychar, similar methods in general are followed. The comparatively few fields and

gardens are well watered from the abundant streams which have their rise in the Mounts Gerizim and Ebal, making it a spot of beauty in the midst of wild and unreclaimed surroundings. In one or two instances here there have been made some efforts at a more enlightened system of irrigation, the water from the clear and copious springs being conducted by an aqueduct of stone masonry and more satisfactorily supplied. The result is the luxuriant gardens in which most of the various kinds of fruits and vegetables suitable to the climate are found, testifies as to what might be accomplished were more intelligent, systematic, and thorough measures adopted.

Throughout Palestine very little water produces a wonderful result. The soil, naturally fertile, immediately responds to the effect of the periodic rains. The bursting of the land into bloom after the first heavy showers of the rainy season is a sight never to be forgotten. The hillsides and valleys, that through the dry season had lain burned up and barren, like a calcined bone, are suddenly, as if by miracle, turned into a garden of the most brilliant blossoms, the scarlet ranunculus and anemone, pomegranate, and many other flowers and shrubs only known to us in cultivation, "making the wilderness and solitary place rejoice and blossom as the rose."

THE KING'S GARDEN, JERUSALEM.

In the valley of the Kedron, on the southerly side of Jerusalem, is the King's Garden, which dates back to the time of Hezekiah, if not to that of Solomon. It is mentioned in Nehemiah (2, 15), where it speaks of "Siloah, by the King's Garden."

The few acres which are at present under cultivation here are irrigated in the usual simple manner. The source of the water supply is the celebrated Pool of Siloah, or Saloam, a reservoir 53 feet long, 18 feet wide, and 19 feet deep, which is fed through a subterranean conduit by the overflow of the Pool of the Virgin, an intermittent spring about one-quarter of a mile to the northward. The water is conducted from the former pool partly by underground drains, regulated by the most primitive of sluices, into smaller channels in the direction required, where still finer ramifications, or branches, distribute it to the drills, or rows, in which the crop is planted, much as in the other instances mentioned and with as little regularity or system.

In those garden plats all the ordinary vegetables and many kinds of fruit are produced in good quantity and of fair quality.

And up the terraced slopes, even to the very walls of Jerusalem, some of the largest cauliflowers come to perfection, and are in the market in the months of February and March. This vegetable sells at the rate of 3 heads for 12 cents.

There is no special regulation as to the use of the water, other than that of the most patriarchal kind, the owners of the adjacent land having free access to the pool for all requisite purposes, including household uses and the watering of their flocks and herds. Much of the water is also brought into Jerusalem for sale in goatskins.

KING SOLOMON'S POOLS AND GARDENS.

About 8 miles to the southwest of Jerusalem are the wonderful Pools of Solomon, while below them, in the narrow valley of Urtas, lie the renowned gardens of the wise King, except the Garden of Eden I

suppose the oldest recorded gardens in the world. These works are mentioned in Ecclesiastes (2, 4-6), as follows :

I made me great works ; I builded me houses ; I planted me vineyards ; I made me gardens and orchards, and I planted in them all kinds of fruits ; I made me pools of water, to water therewith the wood that bringeth forth trees.

There is little doubt, too, that the scenes depicted in that beautiful oriental love song—"The Song of Solomon"—found here their original. Josephus also speaks of this place, "very pleasant it is in fine gardens, and abounding in rivulets of water," and tells us that Solomon was wont to visit it frequently, describing him as driving out there in the morning, sitting on high in his chariot, clothed in white, and surrounded by his handsome mounted guards, all of great stature and in the flower of manhood, arrayed in Tyrian purple and in armor, their long hair sprinkled with gold dust.

It would be difficult to overestimate the noble character of those remarkable works, especially considering the period in which they were constructed.

The pools consist of three enormous reservoirs, partly cut in the rock, partly built of massive marble masonry. Their dimensions are as follows : The upper pool, 380 feet long ; breadth at east end, 236 feet ; at west end, 229 feet ; depth at west end, 25 feet.

The middle pool, which is distant from the upper pool 160 feet, is 248 feet long ; it is at east end 250 feet broad and at west end 160 feet ; while the depth at east end is 39 feet. The lower pool, 248 feet eastward of the middle pool, has a length of 582 feet ; a breadth at east end of 207 feet, and at west end of 148 feet, and a depth at east end of 50 feet ; having sufficient capacity, as Dr. Thomson has said, to "float the largest man-of-war that ever ploughed the ocean." Each pool overflows successively, by regulated sluices, into the next below it, in the order here given, the last pool emptying its superabundant water into the valley.

Those venerable structures are, at the present time, in an excellent state of preservation. They are said to have been repaired by Pontius Pilate, which would be about eighteen hundred and fifty-five years ago.

The source of the water supply is the Sealed Fountain of Solomon, at the foot of a hill, a short distance west of the Upper Pool. This fountain is always kept locked ; hence the name. A flight of twenty steps descends from an arched doorway into an underground vaulted chamber, where four streams of pure and cool water converge. This fountain also afforded, in former times, a constant and abundant supply of water to Jerusalem ; a goodly stream being conveyed by the carefully and skillfully constructed stone aqueduct of Solomon, which demonstrates that they understood, at that early day, the principle of the siphon, into the holy temple inclosure. About 2 years ago, the less ancient Saracenic aqueduct being put in repair, the water was once more brought into the site of the temple area and into the so-called Fountain of the Cup, which stands between the Mosque of Omar and the Mosque Al Aksa, and doubtless marks the site of the brazen laver made by Solomon for the ablution of the priests in their sacrificial worship. But the aqueduct soon again lapsing into disrepair, the water is at present barely conveyed in small quantity as far as Bethlehem, of which town it is the principal supply.

Of the 75 acres of land below the pools, in the valley of Urtas, 25 are under cultivation and are irrigated. Independently of the pools the garden lands of the valley are also largely watered from a separate

copious spring, which has its rise in the side of the mountains and at the foot of the village of Urtas. The soil is a red clay, exceedingly fertile, and to this day the finest fruits and vegetables in the Jerusalem market come from those gardens.

Of the fruits produced may be mentioned apricots, peaches, nectarines, apples, prunes, plums, citrons, lemons, pomegranates, mulberries, figs, and grapes. The vegetables include pease, beans, beets, okra, egg plant, onions, leeks, garlic, potatoes, turnips, cabbage, cauliflower, carrots, cucumbers, pumpkins, vegetable marrow, tomatoes, and radishes.

About two-fifths of the land belong to three Europeans, and the remainder is owned by the native Syrian fellahin peasants.

The distribution of the water is regulated by the old custom or system of "fassels," a night and a day forming a "fassel." Each family owning land there know, from time immemorial, its respective rights and share in the "fassel" of water. Some have an entire "fassel," and again the same is divided among the different members of a family, to irrigate their respective shares of land. The water is carried from one plat to another by drains in the usual simple manner already described. The Europeans who own land there have made, however, a cemented conduit to convey their share of water into their ground. No statistics are obtainable, none ever having been kept, as to the duty of water per acre.

No special rent or fee is paid for the water used, nor are there any charges on the land in connection therewith, the only payments made being the usual government taxes—the "werke" (land taxes) and "ushur" (titles).

Solomon's Pools, the Sealed Fountain, and the aqueduct are public property, and are under the control of the Turkish Government.

JAFFA AND ITS ORANGE GROVES.

The town of Jaffa, looking down from its pleasant elevation on the one side on the deep blue Mediterranean, and on the other on its multitudinous palms and odorous orange groves, may well be considered entitled to its name, which, softened in the Arabic pronunciation to Jaffa, means "beautiful."

The orange groves and gardens and their system of irrigation, though they have been greatly extended within comparatively recent times, have unquestionably an origin of quite respectable antiquity.

The area of land under irrigation at Jaffa would exactly include the space occupied by its orange groves, being nearly one-third of the cultivable ground belonging to the community; that is, of 9,000 acres of cultivable lands, about 3,000 acres are under irrigation.

The orange and the lemon are the chief crops; but other fruits, such as citrons, limes, peaches, apricots, grapes, pomegranates, and melons, and all the ordinary garden vegetables, are also produced in abundance and of fine quality. The vine especially is of late receiving much attention, and within the last few years extensive vineyards have been planted. Neither the vine nor the olive, of the latter of which there are many groves, requires any water other than the usual rainfall.

The superiority of the Jaffa orange is world renowned, whether its size, juiciness, or flavor is considered.

In an average season, oranges and lemons, together with other fruits and vegetables, to the amount of \$335,000 have been exported from

Jaffa. Besides this is the immense home consumption, of which there is no record.

The sources of the water supply are wells, which are fed by underground springs.

The engine in use for raising the water is in every case, without exception, the so-called "bajara" or "bayara," a wooden machine of the most simple construction, driven by horse or mule. Its principal parts are a whim beam or capstan with horizontal wheel attached, moving a vertical wheel connected by shaft with a third wheel which carries at its circumference a chain pendent reversible buckets.

A pole inserted in the whim beam is fastened to the horse or mule, with the monotonous circuit of which animal the whole is set in motion; the wheel with buckets revolving in the well, dipping up the water and emptying it into the conduit or tank. The tanks are usually close to the wells, and are cemented basins built of stone. They are filled during the day, the water being distributed from them, through the various channels, during the night, in order that the loss by evaporation may be reduced to the minimum.

There are about 700 of these bajaras at work at Jaffa.

The system of water distribution, being entirely under private control, is governed by neither law nor regulation.

The quantity of water used per acre during the season of 23 weeks, or 161 days, is 2,300 cubic metres, at a cost of from 20 to 25 cents per diem. Thus, for instance, the average expense for irrigating an orange garden with an area of 5 acres would be, for 160 days, at 20 cents, \$160. The value of the crop might be estimated at from \$500 to \$700.

Owing to the peculiarity of the climate, the orange groves are obliged to be watered during the summer months, or rather during the dry season, when no rain falls; that is from May till October or November. The rainfall in the winter months, or, say, from November till May, varies from 17 to 30 inches. The average temperature is, in the daytime, from 70° to 71° F.; during the night, from 55° to 56° F.

The soil in the orange groves is of mixed clay and sand, with rather more of the latter than of the former. It is exceedingly fertile, and is particularly well suited to the orange.

As to the antiquity of the system of irrigation, the close resemblance of the "bajara" to the Spanish "noria" has induced many persons to imagine its being introduced here at some early period from Spain. But as the family likeness of these wheels to the ancient Persian wooden water-wheel is equally great, and as the Crusaders, in the eleventh century, are reported to have found the orange tree (*Citrus aurantium*) already in Palestine, the actual system of irrigation may as well belong originally to this country, or to the East, and may have been introduced from Persia.

CLIMATE.

In addition to the facts already given respecting the climate of Palestine, I add the following remarks: It is evident from the statements of history, both sacred and profane, as well as from other testimony, that this country, in former ages, was not only under a more general and thorough state of cultivation as regards its agricultural districts, but also that it possessed extensive tracts of forest which have long disappeared. Consequently its rainfall was more favorably regulated, being more equable in its distribution. The result would naturally be not only the temporary advantage of the improved growing crops, but the enrichment of the soil and the permanent benefit of the land. At pres-

ent seasons of almost tropical rain are followed by the long, dry period in which not a drop of rain falls, and nearly every green herb perishes and burns up for lack of moisture. Swept by the resistless torrent of the rainy season, the higher lands are stripped of their soil, and entire districts are seen in which the barren ridges of rock crop out like the bones in the skeleton of some gigantic animal.

The phenomenon of the "air cushion" is seen here to perfection. Before a rain sets in it generally takes several days of incubatory preparation before the result comes. Great clouds roll up, and cover the entire heavens with their dense masses; but in vain they attempt to discharge their contents, or if they succeed in dissolving, the thirsty atmosphere drinks up the moisture before it ever reaches the earth. And this must continue till the intervening strata composing the "air cushion" are sufficiently saturated to permit the rain to fall through, which then occurs in a violent and often injurious downpour. Deprived of the gentle mediation of the growing crops, and especially of the forests, which would have established the proper relations and a just equilibrium, through their continual evaporation, the parched ground languishes for the rain that is denied it, or that, when given, comes in almost an unwelcome shape.

During the serious drought of 1887 and 1888 this phenomenon was seen in an extreme degree; weeks and even months passing without adequate rain, though the greater part of the time the heavens were dark with clouds.

The intervening unsaturated "air cushion" drank up the contents of the clouds, as already described, so that little or no rain could pass through it.

It is thought that the agricultural colonies establishing here within recent years have already begun to produce a perceptibly beneficial effect in this direction. But probably it is too soon yet to look for any decided change.

HENRY GILLMAN,
Consul.

UNITED STATES CONSULATE,
Jerusalem, August 29, 1889.

SYRIA.

RÉPORT BY CONSUL BISSINGER, OF BEIRUT.

AREAS IRRIGATED.

As there are no statistics kept in Syria it is not possible to state, with any degree of positiveness, the exact areas of land under irrigation, and the different authorities competent to speak on so important a subject differ somewhat in their various estimates. A high Government official in Damascus who has devoted much study and attention to the matter gives the approximate area of cultivated land in the vilayet or province of Syria as 30,000 feddans = 336,000,000 square feet. (A feddan in Syria is understood to comprise that extent of land which can be plowed and prepared for seed by a pair of oxen in one day.)

An equally reliable and competent authority in Beirut, from his own observation and knowledge of the country, estimates that only about 5 per cent. of the cultivated lands are irrigated in the province known as

Mount Lebanon, and probably not over 2 per cent. in all Syria, while the proportion of irrigable as compared with nonirrigable areas is calculated by the former authority as equal to about 3 parts out of 24, or 12½ per cent.

CROPS.

The total quantity of crops grown is not ascertainable, not even approximately, and any attempt to arrive at exact figures would be useless and a mere waste of time.

The quality of the crops varies according to climate, soil, and locality; they comprise nearly all the cereals grown in the United States, besides "durah" or maize, both yellow and white, sesame, hemp, cotton, etc., also bananas, pomegranates, figs, dates, oranges, lemons, mulberries, olive and other fruits, and all kinds of vegetables and other garden products.

Orchards well watered, as those for instance at Sidon, Tripoli, and other places in Syria, are reputed to be very remunerative in a pecuniary point of view, yielding, it is said, as high as 10 per cent. on the capital invested clear of all expenses.

WATER SUPPLY.

The sources of water supply are lakes, rivers, streams, and other water courses, springs, ponds, wells, and cisterns or tanks. The waters of lakes for irrigation purposes are only utilized in a few instances, such as Homs, Tiberias, etc., as will be seen later on, and reservoirs on a large scale do not exist at all in Syria.

MODES OF IRRIGATION.

Published reports of irrigation and storage works do not exist; a wood cut of a huge Persian water-wheel, in use at Hamath, with an accompanying description in print published from notes furnished by a competent authority here, is annexed to this report, designated as annex "A."

Generally speaking the character of the irrigation works is of the most primitive kind. From rivers the conveyance of water is usually by means of canals or rough ditches badly leveled and aligned, often without masonry except at intake, the retaining weirs for the obtaining necessary head being remade every season of boulder, stones, and brushwood, rarely over 3 feet high.

Irrigation from springs is generally much the same as from the rivers, though necessarily on a smaller scale.

From wells the system universally employed is that of the "Na'hura." The "Na'hura" is of the simplest construction, cheap, quickly made and repaired and easily worked, while it raises a comparatively large quantity of water. Its construction consists of a clumsy cog-wheel fitted to an upright post and made to revolve horizontally by a donkey, mule, or horse attached to the sweep; this turns a similar one perpendicularly placed at the end of a heavy beam which has a large wide drum built into it, directly over the mouth of the well.

Over this drum revolve two rough hawsers or thick ropes, often made of myrtle twigs and branches twisted together, and upon them are fastened small earthen jars or wooden buckets. One side descends while the other rises, carrying the small buckets with them; those descending are empty, while the ascending ones are full, and as they pass over the top, they discharge into a trough which conveys the

water to the cistern. The length of the hawsers and number of buckets depend upon the profundity of the well, for the buckets are fastened to the hawsers about 2 feet apart. The wells are of different depths, but generally average from 10 to 15 feet. It is claimed that with good animal power a bucket containing about 2 gallons of water can be raised every second. (See table in "Acca-Haifa" report.)

The "Shaduf," so conspicuous on the Nile, is not used in Syria; but on the shores of Lake Tiberias an apparatus much like it has been seen at work, and the well sweep and bucket is also met with in many places.

Another method (very common in the land of Philistia) may be observed on the plains of Central Syria. It is a large buffalo skin, so attached to cords that when let down into the well it opens and is instantly filled, and being drawn up, closes up so as to retain the water. The rope by which it is hoisted to the top works over a wheel and is drawn by donkeys, mules, oxen, or camels that walk directly from the well to the length of the rope and then return, only to repeat the process until a sufficient quantity of water is raised; this is also a very successful mode of drawing water.

The wheel and bucket of different sorts and sizes is much used where the water is near the surface, and also along rapid rivers. For shallow wells merely a wheel is used, whose diameter equals the desired elevation of the water. The rim of this wheel is large, hollow, and divided into compartments answering the place of buckets. A hole near the top of each bucket allows it to fill, as that part of the rim, in revolving, dips under the water. This, of course, will be discharged into the trough when the bucket begins to descend, and thus a constant succession of streams falls into the cistern. The wheel itself may be turned by donkeys, mules, oxen, or camels.

Small water-wheels are sometimes turned by feet, but the process is tedious, toilsome, and not productive of much result.

At "Homs," in the Tripoli district, there is a lake or artificial basin of about 4,000 acres in extent, formed by draining the "Orontes" River. It is very shallow in summer, probably not over 10 or 15 feet at the deepest part, but will reach a depth estimated at from 30 to 40 feet in the winter. The lake was made for the double purpose of regulating the summer flow of the "Orontes" and for obtaining sufficient head of water to irrigate the extensive gardens of Homs. This lake is the only artificial system of irrigation on a large scale in the country, but it is not kept in very good repair.

The Pools of Solomon at Tyre may also be mentioned; they are natural artesian wells of great volume, irrigating some 1,500 acres of garden land by artificially raised conduits.

WATER DISTRIBUTION.

In regard to this, Ottoman law literally says:

The contestations relative to water courses for drinking or irrigating purposes, the customs and usages existing "*ab antiquo*" only are to be taken into consideration.

These usages and established rules vary somewhat in different localities, but it is the almost universal custom that the water belongs to the community and to the lands irrigated by it; the allotted quantities of water can not be altered or alienated without the permission of all the proprietors unanimously, nor can the lands be sold without the water, nor the water without the lands.

The amount of water used per acre is estimated by a reliable authority as varying from 25 tons in the plain for garden products to 4 tons per acre in the high lands for mulberry trees.

The actual or precise quantity of water used per acre or season can not, however, be accurately stated; it varies greatly according to the soil and its products. Mulberry trees, for instance, need only to be well watered three or four times during the dry season, but the water should penetrate the ground at least 3 feet; this would require the land to be inundated to a depth of at least 8 to 10 inches. Vegetables, cereals, etc., should be watered more frequently, at least once or twice a week. Where there is scarcity of water judicious manuring would do much towards assuring good crops, but this practice, outside of the vicinity of Beirut and other large cities, is either wholly unknown in Syria or only resorted to in very isolated cases.

The Turkish regulations and laws in regard to the tenure of ownership of water, etc., are very comprehensive and precise on the subject, and for a fuller understanding of the same a translation of the most pertinent paragraphs is appended herewith:

OTTOMAN WATER REGULATIONS AND PROPRIETARY RIGHTS.

Water, herbs, and fire, are things *ex commercio*; all men enjoy them in common.

Water running under ground is the property of no one in particular.

Wells not sunk by any one in particular, and which are used by the public in common, are *ex commercio*.

Seas and great lakes are things *ex commercio*.

Streams of the public domains, that is to say, those which do not specially belong to any one, are those whose bed is not the property of a number of persons; such streams are *ex commercio*, as for example, the Nile, the Euphrates, the Danube, etc.

Private streams (Arabic: Euharmemionké) i. e., those whose beds traverse the lands the property of private persons, are of two kinds:

1. Those waters are subdivided among coproprietors, but which do not empty or exhaust themselves completely into the lands of the latter, and which run afterwards into public rivers; such water courses are also designated public because part of them is public domain; the right of preëmption is not applicable to these water courses.

2. Private water courses (néhrihass), which run within the limits of the property of a given number of persons, and whose water is exhausted and disappears upon such property without reappearing to form another confluent; preëmption rights are only applicable to such water courses.

Alluvium deposited by a stream on the land of a private individual becomes that person's property; no one else can lay claim to proprietary rights thereto.

Herbs of natural (wild) growth upon lands the property of no one in particular are *ex commercio*, the same with herbs that grow upon private property unknown to the owner; but if the latter waters his land or incloses it with a view to prepare it for cultivation then the herbs growing thereon become his property; no one else can appropriate them, and he who gathers them is held responsible therefor.

By herbs are meant such plants as are not artificially watered; mushrooms, for instance, are included therein, but trees are not.

Trees of natural (wild) growth upon mountains, which have no owners (djibali monbaha) are *ex commercio*.

Trees of natural (wild) growth upon the property of any one belong to the owner of such property; nobody can cut them down without his authorization. He who grafts a tree becomes the proprietor of the shoots and fruit thereof.

If anybody occupies a thing *ex commercio* he becomes the exclusive proprietor thereof.

Examples: The water which a person draws from a stream with a receptacle becomes his undisputed property, and if a third person consumes it without the owner's permission he is held liable therefor. The occupation of a thing must show intent; consequently he who has placed a receptacle with the intention of collecting rain water becomes the owner of such water. The same with water accumulated in a basin or cistern; but the rain water found in a receptacle not expressly placed for such a purpose is not the property of the owner of the receptacle, and other persons may appropriate such water.

It is necessary in the occupation of water that it does not run continually; so, for instance, well water, which filters through, is *ex commercio*. He who consumes the

water thus obtained by infiltration, even without the proprietor's consent, is not held liable for damages. Again, water is not considered as having been appropriated where as much enters a basin on one side as escapes on the other.

Everyone may enjoy a thing *ex commercium* on condition that such enjoyment causes injury to no one.

One can prevent a person from occupying or appropriating a thing *ex commercium*.

Everybody can utilize the waters of public streams for his lands, and may for this purpose or for the purpose of constructing a mill, dig canals and ditches or trenches, on condition, however, of doing no injury to anyone. Works which cause an inundation, those which completely exhaust a stream, or which prevent boats (barges) from floating, are to be interdicted.

Man and beast may drink of the waters not the individual property of any one. The right of "chirb" (the right to use water for irrigation and for the consumption of animals) of water courses not public property belongs to the owners of these streams (courses); any other person, however, may drink therefrom. Thus no other person than the owner can serve himself of the waters belonging to a community or of a ditch, trench, or well, for irrigating purposes, but he may drink therefrom and even water his animals, provided the number of these be not so large as to damage the water course, the canal, ditch, trench, or conduit; he can likewise draw water therefrom with a pitcher or pail and carry it to his house or garden.

Those who possess a brook, stream, basin, or well upon their lands whose waters are renewed by nature may prevent anyone who wants to drink therefrom from entering their property; but if there exists no other water *ex commercium* in the neighborhood the owners are obliged to either offer the use of their water or allow their lands to be penetrated; and in case they fail to offer their water those who wish to drink may enter the property, provided no harm is done thereto by damaging, for example, the edge of the wells or the water conduits.

One of the coproprietors of a common water course can not, without the permission of the others, cut a channel, ditch, trench, or gutter. He can not change his "turn" or share of the enjoyment of the water established *ab antiquo*, nor cede such right to a landed proprietor who has no right to the waters of such a river for irrigating his field or watering his cattle.

The authorization to perform these acts given by the other coproprietors could be revoked by these latter or by their heirs.

In all contestations touching drinking water or water for irrigating purposes the rules, regulations, and usages established *ab antiquo* are to be enforced.

The waters of rivers, streams, springs, and other water courses passing through the lands of a village or a city are the property of the community, and must be distributed, as has been the practice *ab antiquo*, in such a manner as to secure a supply to each landed proprietor during certain hours, either weekly or fortnightly.

Every owner of land knows the exact time and quantity of water to which he is entitled, and in almost every village there is a civil officer who is charged with the duty of looking after the proper allotment and distribution of the water among all the inhabitants.

As clocks and watches are not commonly in use among the peasantry, the time is measured by various devices, such as hourglasses, etc.

IRRIGATION WORKS.

Besides the Beirut waterworks noticed under the head of "General remarks," there exist in Syria no irrigation works which supply water against payment, and the Turkish Government has no other interest, nor claims any other right to rivers, streams, springs, and other water courses than to place an increased valuation upon the lands irrigated therefrom, and to levy a comparatively heavier land tax.

CLIMATE AND SOIL.

The climate of the coast region is warm and damp. Thermometer ranges from about 40° to 90° F. (in the Lebanon and other mountains the range is from 10° to 20° less in the winter and from 5° to 15° in the summer). The climate in the interior is generally dry, but with

greater thermometric range, say 25° and 30° to 90° and 95° F. The following table will show the average readings in Beirut during a period of 11 years.

Thermometrical observations (Fahrenheit) taken at the Syrian Protestant College at Beirut, from 1879 to 1889.

Month.	1879.	1880.	1881.	1882.	1883.	1884.	1885.	1886.	1887.	1888.	1889.
January	60.92	62.20	61.70	56.70	56.20	54.60	56.60	60.20	55.54	55.30	57.10
February	65.24	58.60	56.00	53.20	56.60	55.30	59.30	59.50	57.52	59.60	60.64
March	62.33	57.81	61.70	62.30	64.40	60.10	62.40	59.70	61.10	64.50	63.16
April	69.26	55.70	67.40	66.00	65.60	68.40	65.80	64.60	67.64	66.50	65.84
May	73.88	70.30	71.70	69.60	70.78	71.16	74.60	70.70	72.36	70.80	71.06
June	81.35	79.50	77.40	78.10	78.65	71.90	78.40	78.90	78.64	76.60	78.12
July	85.75	82.88	82.60	81.40	81.90	80.25	82.50	81.70	82.66	83.75	82.67
August	84.20	84.40	85.60	82.06	83.47	82.00	83.30	83.05	83.97	83.60	.....
September	82.65	81.20	82.90	81.70	81.55	78.50	80.90	81.90	81.00	81.00	.....
October	74.96	77.90	76.50	74.64	76.90	74.20	76.80	75.40	79.77	78.52	.....
November	67.55	71.80	67.42	68.16	67.30	66.62	68.90	65.00	70.84	66.22	.....
December	60.58	59.50	60.80	61.00	60.60	63.80	62.40	61.60	62.50	58.38	.....

No statistics for the interior are known exist.

The soil throughout almost the entire vilayet of Syria is of a heavy, clayey (argillaceous) nature, which, in drying up, becomes very hard, causing it to crack; in Beirut and other localities the experiment of using sand to improve the soil has been successful, but on a more extensive scale and upon large tracts this process would perhaps not prove practicable or feasible.

The character of climate is generally very good in the plains, but better in the mountains; the lands not irrigated are of course the most salubrious; the nonirrigated districts in the Hauran (east of Damascus) are considered by far the best; next come the regions to the north; then the Baalbec district, the plains of the Bekaa or "cool Syria," and the districts of Hasbaya and Rashaya. The land around Damascus is all irrigated and the soil is very fertile.

ANNUAL RAIN-FALL OR OTHER PRECIPITATION.

Along the coast, near Beirut, the annual rainfall averages about 30 to 38 inches, but in the interior it is much less. One authority estimates it as low as 15 inches, while another makes it from 15 to 50 inches, or an average of 32½ inches. The rainfall for Beirut for a period of 10 years and 6 months is herewith annexed.

Rainfall (in inches) at Beirut from 1879 to 1889, observed by the Syrian Protestant College at Beirut.

Month.	1879.	1880.	1881.	1882.	1883.	1884.	1885.	1886.	1887.	1888.	1889.
January	3.10	9.33	1.32	4.91	12.75	10.639	10.37	5.82	8.91	6.065	6.93
February	2.23	4.205	9.44	10.18	9.251	6.065	4.165	9.365	2.56	6.025	2.885
March	5.8	3.585	5.86	1.325	3.305	2.650	1.64	8.26	1.685	2.745	2.59
April	0.64	2.125	2.976	6.25	0.90	1.664	3.43	0.58	0.35	5.158	.84
May	0.77	0.48	.....	2.57	0.35	0.547	0.05	0.42	0.275	0.17	.100
June	.....	.....	0.11	0.06	.....	.....	0.40	.....	.....	.905	.23
July	.....	0.38	.....	.....	0.29	0.01	.....	.....	.....	.....	.....
August	.....	.....	.....	.....	0.085	.....	.....	.....	.....	.....	.....
September	0.12	1.018	0.785	.....	1.01	0.70	0.625	.....	0.14	.045	.....
October	3.39	0.51	1.385	3.125	2.115	1.936	0.06	2.205	.....	1.330	.....
November	4.56	1.05	5.54	3.10	15.304	4.35	3.91	3.66	3.065	7.22	.....
December	18.375	9.605	5.76	6.357	6.448	0.24	6.91	5.46	10.17	7.865	.....
Total	33.685	32.343	32.665	37.877	50.713	30.136	31.655	36.995	27.255	38.148	.....

Annual average during 11 years, 35.146 inches.

No statistics are kept of the amount of the annual rainfall in the mountains and the interior, but it is variously estimated at from 15 to 50 inches according to locality.

PRECIPITATIONS.

Dec.—During the summer and the fall more or less plentiful. Very plentiful in spring, sometimes sufficient to ripen the grain when rains cease early. In February, March, and April hail storms are not uncommon. If they occur late they are apt to destroy the mulberry leaves and the vine. Snow falls on the mountains and in the interior, but no statistics are kept of the quantity.

Generally the country is at least 5 months without any rain at all, and a month after the last rainfall the land is dried up to the depth of the roots of the trees, causing a total cessation of all vegetable life unless irrigation is resorted to. May is the last month in which rain falls, but the copious downpours really cease with the end of March or beginning of April.

ANTIQUITY OF IRRIGATION.

All the existing irrigation works are of considerable antiquity; some date from time immemorial. On the right banks of the Dog River, about 5 miles north of Beirut, there still exists an old aqueduct, built upon arches and partly cut through the solid rock, running along the river side, which is said to date back to the time of the Roman occupation; its present use is to convey water for the irrigation of a vast tract of land and to furnish the domestic supply for the village of Junié, etc.

The ruins of another aqueduct, where the water was conducted over river and dale, are still to be seen in the valley of the Beirut River, about 8 miles above its mouth.

The waterworks and conduits of Damascus, Tripoli, Homs, and Hamath are also of great antiquity, and the water is conducted by means of canals of masonry, or, where this was impracticable, through earthen pipes and sometimes also through stones scooped out for this purpose.

The ancient canals in the plains of Mesopotamia, between the Euphrates and Tigris, are still extant, but they are choked up with the accumulated rubbish of centuries, which with a little energy and hard work could easily be removed.

No maps or publications bearing upon the subject of irrigation, etc., exist in the province of Syria.

GENERAL REMARKS.

Under-irrigation works are usually placed on lands lying along the foot of a mountain, from which rivers, streams, springs, or other water courses flow, and which by reason of their gentle slope adapt themselves admirably for irrigating purposes.

In Beirut the area under irrigation extends about 5 miles in one direction and 8 to 9 in another, and the necessary supply of water is furnished by the Beirut River conducted through five canals. Another strip of varying width and about 12 miles in length runs along the Mediterranean Sea, and is irrigated by the waters of the Dog River, the powerful spring of Antelias, and other springs of minor capacity.

The irrigated lands in these districts are planted principally with mulberry trees for the silk industry, besides all kinds of vegetables and garden stuffs.

At Tripoli the irrigated lands consist mostly of orange groves, about 5 miles square in extent, which require a great deal of water, of which, however, there is no lack, for the river that flows down from Mount Sannin (of the Lebanon range) furnishes an abundant supply; sufficient also for the ancient Tripoli city water works. From Tripoli northward there runs a narrow strip of land between the sea and the mountains, of about 1 to 2½ miles in breadth and about 16 miles in length, irrigated from the waters of springs and rivulets which have their source there. Onions are the principal product of these lands; they are annually exported in large quantities in small sailing vessels.

In the interior of the country, wherever there is artificial watering, "durah," or maize, is generally grown, and is said to be quite remunerative; but it will not prosper without water.

Between Tripoli and Homs, in the valley of the Nahr "Jabir" (River Eleutherus), large tracts of lands are thus year after year planted with "durah." The crop per acre it has not been possible to ascertain with precision, but it is asserted by an eye witness that the best looking of these fields would compare very unfavorably with the corn fields in Illinois, for instance, and that they would probably not produce much more than one-half the average yield of American farms.

Upon the highlands (plateau) traversed by the river Orontes there is very little irrigation, for the river itself has, in the course of centuries, imbedded itself so deeply that the ancient water conduits can no longer be utilized and new ones have not yet been constructed.

The conveyance of water in general is by means of canals or ditches expressly dug for this purpose where they do not already exist, or where the water does not run of itself. The canals are usually very old, but are not kept in very good repair. The waters of springs are carried into cisterns or tanks built of masonry, well cemented, which are usually emptied each day; large reservoirs are unknown in Syria and the maxim among the natives in force is "that irrigation is only profitable where the water runs unaided by man," that is to say, where conduits and consequently pecuniary outlays are unnecessary; their ancestors were apparently of a different opinion, judging from the numerous works left by them scattered broadcast over the land.

Of modern irrigation and waterworks the Beirut waterworks take first rank; they are the property of an English stock company, which furnishes Beirut with an excellent quality of drinking water at fixed rates, as well as a needful supply for irrigating purposes at reasonable charges.

Sidon, a few years since, built a pipe line to convey the waters of a spring or springs, situated about 2½ miles distant, into the city, and the municipality of Homs 3 years ago also contemplated the introduction of waterworks; but the project failed through the opposition of the city of Hamath, which apprehended a decrease and even a scarcity of water for its own supply.

Several efforts have been made by an intelligent and enterprising mechanic established in business in Beirut, a citizen of the United States, to introduce mechanical and steam power as a profitable means of artificial irrigation.

The first attempt made by him was in a region lying between Tripoli and Antioch, a broad plain traversed by a number of rivulets, whose beds, however, had become so deep that canals could no longer be made serviceable as conduits or conveyances of their waters, especially as there was not sufficient fall or headway. A rich Arab, who had seen the irrigation works in Egypt, conceived the idea of applying them practically to his lands situated in the district above mentioned, and

went so far as to order a machine of 5 horse-power. The pump was a Pulsometer, with 4-inch pipes, and the water had to be raised to an elevation of about 30 feet. The pump was guaranteed to lift 750 litres, or 166½ gallons, per minute; it worked for 40 days, fulfilled all its expectations, and would have been capable of irrigating an area of at least 80 acres in extent, but it appears that the fuel proved too expensive—wood being scarce and coal very dear—so that the experiment has been for the present, at least, abandoned.

A second attempt was made in the spring of this year in Hazmyeh in the neighborhood of Beirut, and notwithstanding that the water had to be elevated fully 130 feet, proved entirely successful. The water is first raised about 10 feet from a well, dug close to the Beirut River, by means of a cylindrical pump worked by a steam motor of 3 horse power, and then forced through iron pipes along a hill to the height of 120 feet into a basin holding about 90 cubic metres (3,543 cubic inches) of water for irrigating purposes; the basin can be filled in about 6 or 7 hours, and the capacity per hour, therefore, is about 14 cubic metres, or 551 cubic inches. The investment seems to have proven an entirely satisfactory one in every respect.

A Hallowday wind motor has also been in operation near Beirut for over 4 years, which raises water to a considerable height and works satisfactorily.

In general, irrigation as practiced in Syria, does not entail any greater or other expense than the cost of maintaining the canals, conduits, etc., in good repair, but this, it must be repeated, is not always done.

Irrigation, as has already been shown, is regulated entirely by usage and well-established rules, and every parcel of land has a right to the use of water for certain well fixed length of time; for instance, a small proprietor near Beirut has 5 acres of land; every Friday he can take as much water during 6 hours as he may need to thoroughly saturate his land; if he fails to take advantage of his privilege he simply forfeits it without being indemnified therefor. Where water is scarce, as in many places in the mountains, it is often divided into hours and even fractions of hours, and good care is taken that no one receives or takes more than his allotted share. The sole owner of a spring, a rare occurrence, however, may of course use the water thereof at his own pleasure.

It is worthy of remark that in Mount Lebanon the waters of every spring, no matter how limited its capacity, is caught up into cisterns of good solid masonry and is utilized for irrigating and domestic purposes, and no matter how steep the mountain sides, or how poor the soil, the smallest available and tillable space is planted with onions, vegetable marrow, or egg plant, and three and sometimes even four crops are thus produced each year.

The lands in Mount Lebanon are exceptionally well kept, and the population is principally composed of Christians (Maronites and Greeks, etc.), and Druses, who are quite prosperous, and whose destinies are presided over by a Christian governor-general.

If the foregoing notes do not contain much of practical value or importance for the purposes intended, they may at least serve to impart some interesting, if not useful, information regarding the people of the oldest country, and of their ancestors the Phœnicians, which may not be generally known in the United States.

ERHARD BISSINGER,
Consul.

UNITED STATES CONSULATE,
Beirut, August 24, 1889.

THE WATER WHEELS OF HAMATH.

(Inclosure 1, in Consul Bissinger's report.)

Through the plain of Hamath, in Syria, following a general northerly direction, runs the river Nahr el Aasy, or Orontes. It is fed by the waters of Lebanon. Near the end of its course it bends to the westward, and passing through the valley of Antioch, discharges into the Mediterranean nearly opposite the island of Cyprus. It is the main reliance of the great plain for its water supply. Hundreds of water wheels, some turned by the current, others caused to revolve by animal power, are situated upon its banks. The region depends upon these for its agricultural prosperity.

Where water is to be raised from wells of some depth an endless rope carrying buckets is caused to descend on one side and ascend upon the other into and out of the well. The rising portion carries up the buckets filled. As they reach a certain point they are emptied into an aqueduct and descend again empty. The rope is often made out of branches of the myrtle, as that is so rough that it does not slip. A camel walking round and round in a circle turns a vertical spindle, which by rude gearing works the endless rope of the buckets. Considerable quantities of water can be thus raised. But the characteristic wheel of the "land of Hamath" is different from this. The river itself is the great source of power, and the water wheels turned by the current are largely used. At the principal cities of Horus and Hamath many are employed to supply the personal needs of the inhabitants, and these cities are quite famous for their wheels. The whole region is of great interest in its relation to the books of the Old Testament. Many allusions to the land of, and to the "entrance into, Hamath" occur there.

The wheels vary, not only in character, but in size. Some, such as that just described, are adapted to be turned by a single draft animal, while others are of vast dimensions, sometimes over 80 feet in diameter. They are an important advance upon the Egyptian "shadoof." The latter is a version of the old-fashioned well sweep so common in this country. A pole works upon a fulcrum, is weighted at one end, and carries a rope or pole and bucket at the other. A workman draws down the bucket and fills it, and allows the heavy counterpoise to carry it up. He then empties it into a reservoir or canal. If one man can not raise it high enough, it is dipped out of the canal by another shadoof, and carried to a higher point. In some cases a regularly terraced arrangement of shadoofs is seen.

These, of course, are intermittent in supply. But where the endless rope or revolving wheel is used, a fair approach to continuous operation is attained. The wheel is called "na'urah" in Arabic. We illustrate in the engraving one of the largest, from a photograph of the city of Hamath.

The city, the ancient Epiphania or Hamath, lies about 120 miles north of Damascus, and on both sides of the river Orontes. The city is supplied with water by about six of these wheels, which deliver water into elevated conduits. Each wheel and conduit is owned by a separate company. They are undershot water wheels. The river is partially dammed, a combined causeway and dam securing the necessary difference of elevation or head of water for the running of the wheels. A portion of this causeway appears in the foreground of the view. A chute or flume is thus formed, and the great wheel towers up from the flume and ceaselessly rotates.

Around its periphery is a series of buckets. As these descend on one side into the water they become filled. The wheel turning carries them up full on the other side until a point near the top is reached. There they are discharged into an elevated aqueduct through which the water flows into the city.

The city has a population of 30,000 or 40,000 souls. Of these, three-quarters are Moslems, and most of the rest Greeks or fellahs. This great population depends upon these wheels for its water supply. They are, despite their great size, of quite primitive workmanship and of low efficiency. They are constructed entirely of wood. Much of their expense is involved in the cost of repairs. This item is necessarily large.

The whole region is far from modern civilization. There are no railroads for the transportation of heavy material, and there is no supply of fuel. Hence steam pumps are not available. The population of the country parts are largely devoted to agriculture, and could use any quantity of water. It would seem that in this great plain a field for enterprise might be found for some of our hydraulic engineers.

In Egypt the introduction of improved machinery for raising water has had the most beneficial results. In the plain of Hamath, with its cities of Horus—the ancient Emesa—and Hamath, is another region adapted for such work.

The city of Hamath is now insufficiently supplied, both as regards quantity and head of water. From a letter recently received from Mr. John Baetzner, who had recently visited the city, we hear that the authorities and citizens alike are complaining of the deficient supply. When a place so completely oriental as this makes



such a complaint, it indicates an unmistakable want. By the dams a head of about 8 feet of water in the river at the city is secured. There would appear to be but little trouble in causing this to work improved water wheels, turbines, or undershot, which might be made to drive pumps; or some system of hydraulic rams might be available.

Our correspondent believes that such improvements could be advantageously introduced. While Turkey and its dependencies are very poor, it is under such conditions that economy is imperatively necessary. Improved machinery always effects an ultimate saving, though its first cost may seem great.

ACCA AND HAIFA DISTRICTS.*

[Inclosure 2, in Consul Bissinger's report.]

The Acca-Haifa district and the region of the Hauran probably offer little in the way of irrigation that will prove of much value or interest, for the purpose of the State Department would appear to be to secure information of a practical character on a large scale.

AREAS UNDER IRRIGATION.

There practically do not exist in Galilee, in Nablus, or in the Jordan Valley any irrigation works in the full sense of the word, as understood in the United States; and land under irrigation in those districts is almost nil, forming but an infinitesimal, probably not more than the two-hundredth part, of the whole arable land.

In the Jordan Valley on the Hulé (Sea of Merom), north of the Batéha and south of the Lake of Tiberias, also in the Wád el-'Arab and Wád et-Tanjibe, the Bedouins irrigate small parcels of about 10 to 60 acres, upon which "durah" (maize) is grown, yielding annually two and even three crops. This result is due in part to the exceptional climate of the Jordan Valley, with its tropical heat (a perfect hothouse), to the rich alluvial soil washed down from the basalt mountains, and perhaps chiefly to the great abundance of water in the Jordan and Hieromax (Arab, Sheri'at el Menádire), whereas the higher regions of Palestine and the littoral of the Mediterranean Sea are comparatively too poor in water supplies to enable their inhabitants to irrigate their lands to any great extent.

The irrigation process in all these districts is of the simplest and most primitive character. In the early morning, or shortly before sunset, young Bedouins, in a seminude state, may be seen roughly constructing from stones and earth a temporary dam to obstruct the waters of a stream or wádi (valley), while others, provided with broad hoes, dig little ditches through which they lead the overflowing waters to be distributed over the parcels it is intended to irrigate, allowing the water free course in the lower lying lands, thus inundating, or rather completely setting them under water. These manipulations are of daily repetition; the dams have to be regularly rebuilt, for the pressure of the water causes their daily destruction, and it is interesting to watch with what assiduity and perseverance these Bedouins are continually remaking and renewing the little ditches or canals, which need their unremitting attention.

Reservoirs, basins, tanks, etc., do not exist, and the systems in practice here will therefore scarcely commend themselves to the inhabitants of more progressive countries.

Here and there along the Sea of Tiberias remains of ancient Roman irrigation works may be met with; but they are in such a deplorable state of dilapidation that of their original construction only a catchment basin remains near the head of the spring, and a portion of a conduit (in masonry) in a fair state of preservation. The original character, or the practical application of these ancient works, can, however, no longer be established or recognized, for the Arabs not only made no use of them, but allowed everything to fall into decay and ruin, preferring the antediluvian ways of their own ancestors to the innovations of the Roman intruders.

The system of water distribution, etc., depends wholly upon local custom, as regulated among the different communities themselves. If several inhabitants of a village, for the purpose of irrigation, desire to utilize a spring in common, they will use and distribute the waters thereof in conformity with local tradition, as sanctioned by the municipal authorities; such at least is the custom or practice in this vicinity. In all cases, the proprietary rights of a village spring remain vested with the community, and the spring itself can never be sold.

* This report was prepared by Consul Bissinger, of Beirut, from material supplied by Consular Agent Schumacher and Civil Engineer Schumacher, of Acca and Haifa.

The climate in the irrigated districts of the Jordan Valley, and in the arable lands bordering the Lake of Tiberias is, on the whole, rather insalubrious, engendering malarial fevers caused by the evaporations (exhalations) during the heat of the day and the rapid cooling off at night; in other words, owing to the sudden change and wide range of temperature.

For habitation irrigated districts are carefully avoided in these parts, and as a rule only negroes are capable of withstanding the deadly effects of the miasma.

According to careful observations and measurements in Haifa during a period of twelve years, the pluviometer registered from 19.69 to 34.04 inches per year; last year it reached 33.86 inches. The yearly average, however, may be taken to be 26 inches.

A draw well is in almost universal use in these regions, and by far the most practical and cheapest method of irrigating small parcels and gardens. The hanani, a sketch of which, in its improved form, as in use by the Haifa German-American colony, is annexed herewith.

The hanani as used by the natives is of a much more imperfect and primitive construction than that of the colonists.

It may be worked by either donkey, mule, or horse (wholly unattended), and can be utilized to a depth of 150 feet; the size of the well buckets decrease in proportion to the depth of the well, to allow the hanani to be worked by a single animal of either of the above species.

The amount of water raised diminishes in proportion to the increasing depth of the well, and the following table will serve to illustrate the practical results observed.

Place of observation.	Depth of well.	Amount of water raised per hour.	
		<i>Feet.</i>	<i>Litres. Galls.</i>
Haifa.....	25	5,200 = 1,144½.	
Do.....	30	4,000 = 889.	
Gaza (Palestine).....	146	2,500 = 555½.	
Sea of Merom.....	15	6,500 = 1,444½.	

4½ liters = 1 gallon.

Of course the employment of steam would greatly increase these figures.

These quantities will vary according to the working capacity of the different animals employed, and the above figures were attained by well-nourished animals, resting 1 hour after every 3 hours of consecutive work. The principal basin is generally replenished in from 6 to 8 hours; it is constructed of masonry and well cemented, and ordinarily has 20 feet in length, 18 feet in width, and 7 to 8 feet in depth.

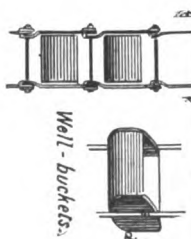
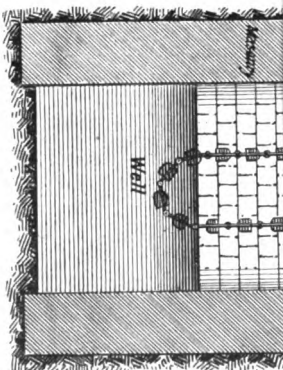
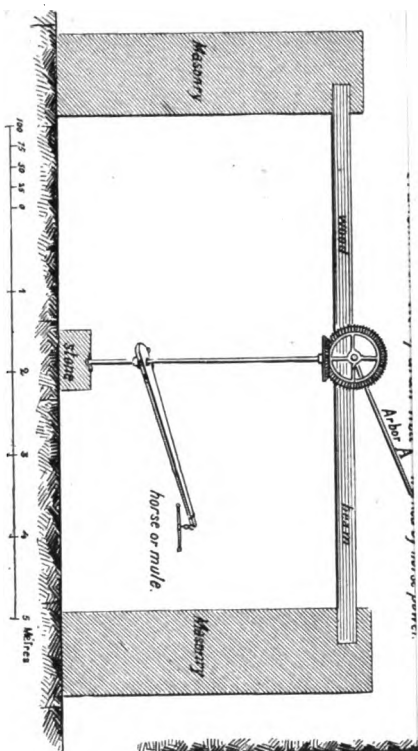
The main basin empties itself into a smaller one 4 feet square by 2 feet deep, from which the water is conducted directly into the main irrigating canal, made of masonry and situated in the most elevated part of the land, which feeds the numerous little ditches that distribute the water over the garden or field to be watered. The hanani is of great durability and seldom needs repairs, especially if the water is free from saline particles; it is of the simplest construction, and can be handled by the most inexperienced person.

MERSINE DISTRICT.

[Inclosure 3 in Consul Bissinger's report—Note by Consul Bissinger.]

In olden times the vast plains of the vilayet of Adana, Syria, were entirely irrigated by the rivers that pass through them. The Romans were in the habit of damming out the required quantity from the waters of the Djihoun, Seihoun, and Cydnus, and conduct it to the foot of the mountains from a high level on both sides of the river, along the surface of the ground, accumulating earth on both sides of its banks, making in this way a wide, high, canal, extending from the mountains on both sides of the rivers in various directions to the sea. The farmers had thus the water within their reach and could easily, and at little expense, by means of subsidiary canals, conduct any portion of it to irrigate their lands.

These long and ancient canals, extending from the foot of the mountains to the sea in all directions, are still extant, and need but to be freed from the rubbish that centuries have accumulated to be again serviceable.



Major Geo. W. 1889

prepared and designed
by
Jesse Schumaker, Major
U.S. Cavalry Regt.

[Note by Consular Agent Dawson, of Mersine.]

In the vilayet of Adana, Syria, there are about 4,740,000 acres of land cultivable, but no irrigation works.

In the plain between Mersine and Adana there are about 400,000 acres irrigable, and between Adana and Missis about 350,000 acres, through which three rivers, the Cydnus, the Sarus, and the Pyramus flow, but up to the present there are no irrigation works, the consequence is that for the last 4 years part of the crops have been completely destroyed and what has succeeded could not be produced at prices to compete against the American and Russian markets in Europe.

The Turkish Government, on the pressing demands of the agriculturist, has recently taken the matter of irrigation in hand, and the Vali Sirri Pacha asked me to assist him in making the necessary surveys and plans, and I have just handed him the plans to irrigate a portion of the plain from Tarsus, towards Adana, for a distance of about 15 miles, which can be done at a very small cost. The other parts of the plain, however, towards Adana and between this latter and Missis will cost about £400,000 to irrigate properly, and although this sum would be comparatively nothing compared with the results, the Government hesitates about the investment, but unless they are carried out by a competent company I am afraid it will be a failure.

The principal crops grown are cotton of very short texture, about 16,000 tons; wheat and barley of second quality, about 25,000 tons; sesame seed of first quality, about 4,000 tons; raisins of very inferior quality, about 4,000 tons.

The soil is partly red and partly sandy. Rainfall averages 22 inches per annum.

The antique irrigations simply consist of the cultivators in the immediate neighborhood of the rivers and mill streams taking advantage of the water passing their farms.

CEYLON.

ANCIENT IRRIGATION IN CEYLON.

[From the report of the Central Irrigation Board for 1888.]

Impenetrable mystery shrouds the origin, and to a great extent the history, of the vast network of tanks and canals with which Ceylon was at one time covered. There is no part of the island, except the central mountain districts, in which the remains of canals and tank bunds are not found; but whether the whole island from Point Pedro to Dondra Head, and from Colombo to Batticaloa, was ever at any one time under cultivation, as some suppose, or whether the population, abandoning or driven from ancient centers of habitation, gradually migrated from one district to another, erecting new works where they settled, and allowing the old ones to decay, is a disputed question. The fact, however, that almost all irrigation works are found on investigation to form but parts of large connected systems, affecting great stretches of country, would appear somewhat to favor the former supposition. The system of the Elahera Canal extends from the Laggala hills, near Mátalé, to Trincomalee. The Yódi-éla of Kalá-wewa, itself 54 miles long, is only one link in a connected chain of tanks and élas, reaching far north into the Mannár district and westward into Kurunégala, and, as recent discoveries seem to show, having its origin at least as far south as Nalanda. Another system, as yet only partially explored, but which becomes more intelligible as the country becomes better known, and of which the river Walawe and the great tank at Pandikulam were the principal features, extended from the foot of the central mountains to the sea on the south coast, while the remains of ancient cities, which are frequent in the Bintenna of Uva, show that the country of the Mahaweli-ganga was also once highly cultivated by the agency of canals, the remains of which are often crossed when traversing the forest.

The ultimate object of all these works was to supply the village fields with water. Where springs exist, where a running stream is available, or where the rainfall of the district is not only abundant but regular, or, better still, pretty evenly distributed throughout the year, it might be sufficient for this purpose simply to build a bund by which to impound the springs, to intercept the stream, or to store up the supply of rain or spring water; and this was no doubt the origin of tanks. But it must have been soon perceived that in many cases this was not enough to insure more than a precarious supply of water, and that to render the irrigation and cultivation of fields perfectly secure, other measures were necessary. The replenishment of tanks, therefore, was provided for, either by conducting any surplus water that might accumulate in one tank into another below it, or by supplementing the supply by means of

a channel from some running stream, or some large reservoir in which the rainfall of an extended catchment area, or the waters of some stream only flowing in the wet season, are stored up for gradual use, as the tanks with which they communicate become exhausted of their natural supply. It was also found that where the canals thus constructed were of any length, they might themselves be used as direct agents for the irrigation of fields below them, and that in some parts of the country where perennial streams abound, a system of small canals afforded a better means of supplying fields with water than a system of tanks.

The village tank, however, was the most ordinary form of water storage, and although there were more or less important differences in the mode of making use of its supply, and of apportioning the fields under it, there was a general resemblance on these points throughout the island, and the diagram on the opposite page of the arrangements for cultivation under a tank in the north-central province, where ancient customs have perhaps been preserved with less alteration than in any other part of Ceylon, will give a fair general idea of similar arrangements throughout the island.

The general customs according to which land under an irrigation channel in Uva were worked have been described by Mr. Bailey, from whose report it appears that all holding land benefited were bound to take an equal share in the repairs of the irrigation channel. Each proprietor was responsible for the proper repair of a certain portion of the channel, and sudden and unforeseen accidents were repaired by the joint labor of all, as was also the dam, or in the case of a tank, the bund. No person was entitled to water if he neglected to contribute to the repairs of the dam or channel, and no new land could be cultivated to the detriment of the existing fields. The fields at the end of the channel were plowed first, and the rest upwards in regular order; and if the lowest fields were not plowed at the proper season they lost their right to priority of water. During the dry season the fields were irrigated by rotation, commencing with those at the commencement of the channel (or nearest the bund, as the case might be). When the volume of any supplying stream was insufficient for the irrigation of all the lands dependent on it, they were divided into portions of such extent as would admit of each being properly irrigated and these portions received the whole volume of the water during succeeding seasons in rotation. The channel was inspected daily and if any field were found irrigated out of its proper rotation the proprietor was held guilty of theft of water. Any violation of these regulations was promptly punished by whipping or fine, and if a royal prison was at hand, by imprisonment also.

Mutatis mutandis, similar rules applied to tanks, and with only slight modifications prevailed throughout the island.

Most, if not all, of the most considerable works of irrigation appear to have been constructed between B. C. 400 and A. D. 1200. After that date, although small works were still occasionally built, no new great works were undertaken, and many of those already existing fell out of repair. Of these many are said to have been wantonly destroyed by foreign invaders, while others were either abandoned altogether during the confusion and distress which attended the onward progress of the Tamil conquerors, or sank into ruin in consequence of the inability of the diminished population to secure their maintenance. All the great canals became choked up; the communications of tank with tank were cut off; the insufficient dimensions of most of the spills soon led to the destruction by floods of a vast number of the tanks themselves when deserted; and such of them as remained unbreached became more or less isolated, and dependent upon precarious supplies alone. Nevertheless, as regarded these, the customs before described were, in the Sinhalese districts in the interior, carefully maintained, although it may be questioned whether, when a bund of great size was breached, or a Yódi-ela silted up, much was done to repair the damage. In the region which had been wrested from the Sinhalese by the the Tamils and occupied by them, even this measure of care does not appear to have been given to irrigation; and in the coast districts under the Portuguese there was probably much wilful damage done by the conquerors; certainly no aid was given by them to the maintenance of the works or support in the enforcement of the customs by which their use was regulated. The smaller tanks in parts of the southern province may have been to a greater or less extent kept up by the people themselves, but no merit for their preservation can be claimed by the Portuguese, under the period of whose rule it probably was that most of the great works in the districts under their influence fell into hopeless ruin.

Wāna (spill)

Wewa (the Tank)

Horowma (Sluice)

Wāna (spill)

We Kanda (Bund)

The fields next the tank are called *Purampota*, or *Mulpota*, or *Upaytpota*.

Ihalap Bayé

The Pahal Wānāto

Pala Bayé

The Ihal Wānāto

The next range is called the *Herenāpota* or *Peralapota*.

The land opened in addition to the above two ranges is called *Katta Kaduwa* or *Alut Aswēdduma*.

	KURULLA PALUWA
	INALA ELAPATA
1	BARWASANA
2	ELAPAT PANGUWA
3	PANGUWA
4	"
5	"
6	"
7	"
8	"
9	"
10	"
1	PANGUWA
2	"
3	"
4	"
5	"
6	"
7	"
8	"
9	"
10	"
	PAHALA ELAPATA
	KURULLA PALUWA

	KURULLA PALUWA
	INALA ELAPATA
1	PANGUWA
2	"
3	"
4	"
5	"
6	"
7	"
8	"
9	"
10	"
1	PANGUWA
2	"
3	"
4	"
5	"
6	"
7	"
8	"
9	"
10	"
	PAHALA ELAPATA
	KURULLA PALUWA

	KURULLA PALUWA
	INALA ELAPATA
1	PANGUWA
2	"
3	"
4	"
5	"
6	"
7	"
8	"
9	"
10	"
	PAHALA ELAPATA
	KURULLA PALUWA

CHINA.

CANTON.

REPORT BY CONSUL SEYMOUR.

AREA IRRIGATED.

Irrigation of land is so general in southern China that a comparison between irrigated and non-irrigated lands is impossible.

Rice is the chief crop on which cultivators rely for support; but near Canton and other large towns and cities a great diversity of productions may be found, as vegetables of all kinds are cultivated; and the lands being so subsidized as to be devoted, in small parcels and under the management of small owners, to many kinds of crops, with a view to early supplies for immediate city consumption.

The yield of an acre of good land, which has been properly fertilized and irrigated, supports a family of five persons, who will each consume 2 pounds of rice, and other things in moderate variety and supply. Two crops of rice and one of vegetables are produced annually where the land is well tilled. A ton and three-quarters of rice per acre each year is a fair crop. In tilling the small pieces of land about Canton, with a generous use of fertilizers, the utmost vigilance is given to irrigation.

SOURCES OF WATER SUPPLY.

The sources of water supply are the small tributaries of the larger branches of great streams; and in many places, where these are inaccessible, pools of water are held in reserve by hardening the bottoms and sides of pits and hollows, and depressed or sunken lands. Return rows of growing vegetables, trenches filled with water obtained from the creeks, brooks, or pools, are kept; and once or twice a day the water is scooped from these trenches upon the raised ground, in which the roots have great depth of loose and moist soil to promote growth. When these trenches of water are not available, owing to scarcity of water, or to porous land, the men and women carry, suspended from a yoke across their shoulders, two large buckets with long spouts, and sprinkle the rows of vegetables copiously. Sometimes the water for this purpose is carried in buckets a considerable distance.

For the irrigation of rice lands which have to be submerged, the lands are divided into small patches at different levees, so that the appearance is that of a beautiful system of terraces, near a bountiful supply of water, which is raised to the upper level of chain-pump and thread-mill process with cooly power.

From the upper to lower levees the water descends so gradually as to avoid washing away the substance or fertility of upper to lower lands.

WATER DISTRIBUTION.

The system of water distribution is generally conducted and used on the mutual or coöperative plan, which prevails in China in so many branches of industry and business as to lead one to believe coöperation is reduced to a perfect system on the basis of equity.

CLIMATE AND SOIL.

The character of the climate in this province is mild and warm. The lowest temperature at Canton in winter is about 37° or 38° F. The rainy season of March and April, with copious showers and rains of considerable frequency during May and June, and occasional showers up to the end of August, supply the crops with abundant water when most needed, for the first and second rice crops.

The actual measurement of rainfall is not known. During the rainy season the water fall is torrential at times.

ANTIQUITY OF IRRIGATION.

The antiquity of the irrigation system in China is established. This portion of China is favored with streams, water ways, sloughs, and natural deposits of water for the temporary season of drought; so that, besides abundance of fertilizing properties being available for agricultural and horticultural operations, the excellent supply of water required for irrigation of land favors the production of the largest crops of which any land is capable of yielding.

CHARLES SEYMOUR,
Consul.

UNITED STATES CONSULATE,
Canton, China, August 12, 1889.

NEW CHWANG.

REPORT BY VICE-CONSUL BANDINEL.

The market gardens in the immediate vicinity of three important cities are irrigated from wells situated in and belonging to the owners of each.

The water is raised by a sort of endless chain worked by animal power; falls into a large triangular wooden trough, and thence into brick or stone channels which conduct it through the garden.

The use of the water wheel appears to have been introduced within the last 40 years by the French missionaries; prior to that date the water was raised by hand labor with a windlass and rope.

With the above exceptions it does not appear that irrigation is practiced in these provinces, which is the more strange as the spring crops are frequently ruined by drought which might be easily counteracted by irrigation from the numerous streams with which some parts of the country are intersected.

The water obtained from each well is only used for irrigating the proprietor's own garden, and the system of irrigation, such as it is, is maintained at the private expense of the respective proprietors, and without interference from the local or State officials.

J. J. FRED'K BANDINEL,
Vice-Consul.

UNITED STATES CONSULATE,
New Chwang, February 19, 1890.

NINGPO.

REPORT BY CONSUL PETTUS.

AREA IRRIGATED.

It is impossible to ascertain the areas of lands under irrigation or cultivation, owing to the difficulty in getting at the records kept in the tax office and the absence of published returns of land taxes. The district is well cultivated, and every strip of land available is under cultivation.

WATER SUPPLY.

The supply of water for bottom land is from canals. The supply canals are run from the river to the hills, dug from 50 to 80 feet wide. At the foot of hills all running water from springs is emptied into the canals, so as to form a never-failing supply of fresh water. The canals are not allowed to connect with the river, as the water in the latter is salt or brackish. At the foot (or end) of the canal an embankment of stone is made to a height above the tides of the river. This is covered with moistened slippery clay, so that boats entering or leaving the canal are hauled over. A hawser of twisted split bamboo is fastened either to the stern of the boat or a strong beam crossing it at the bows. The hauling is usually done by capstans, sometimes by oxen.

These canals have no locks. The supply canals are from 2 to 4 miles apart; minor canals are dug at right angles, and supplied with water from the main arteries, about 200 to 400 feet apart, from 10 to 30 feet wide; thus every farm and garden is supplied with free water.

MODES OF IRRIGATION.

The farmers, when compelled to irrigate their land, use a wooden chain pump, which is as long as required, placed so as to draw water from the canals, worked by cog-wheels, the ox performing the labor; so a stream of water some 10 inches wide constantly flows. A field of 2 or 3 acres of rice is soon overflowed.

For gardens and small plots of ground a hand pump of the same kind is used, generally worked by 2 men.

The hill lands are terraced and are irrigated by springs, water being conveyed by small ditches or by pipes made of bamboo.

WATER DISTRIBUTION.

There are no laws or rules governing the water system. The canals are free, and there are no expenses to the user beyond those of drawing the water from the canals.

CLIMATE.

Climate damp and warm from April to July; July, August, and September hot and dry; November and December dry and pleasant; January, February, and March damp and disagreeable.

ANTIQUITY OF IRRIGATION.

The system of irrigation, according to Chinese, is over 1,000 years old. The soil is alluvial. Rainfall for 1888 was 68.31 inches.

THOS. F. PETTUS,
Consul.

UNITED STATES CONSULATE,
Ningpo, August 20, 1889.

PROVINCE OF FO-KIEN.

REPORT BY CONSUL CAMPBELL. OF FOO-CHOW.

RICE CULTIVATION.

As the rainfall is equably distributed throughout the year in this province (Fo-Kien) there is no land dependent alone on irrigation, but in the culture and growth of rice which is generally understood to be the principal crop grown here, irrigation is at times indispensable and is a subject which deeply concerns the farmer in this country. The rice crop can not be made without a great deal of water and in the seasons of drought its absence is sorely felt.

In the first place a small piece of ground is highly fertilized, plowed or dug up and put in good order very much as cabbage beds are prepared, then the rice seeds are sown after which the water is turned on and the bed kept submerged with about a half of a foot of water until the plants are sufficiently large to be transplanted to the fields. And here again irrigation is required. The ground is plowed and put in order for the plants, but before planting the fields are covered with water about one-half of a foot deep and the soil is worked into mud. The plants are then set into the mud and water in rows. Water is kept standing on the land until the plants are well along. Irrigation is therefore essential to rice growing.

WATER SUPPLY.

This country is well situated for the construction of reservoirs on a large scale. Dams could be easily built across the gulches and deep cañons in the mountains and reservoirs could be made wherein immense quantities of water could be stored, and when needed for irrigation could be turned on the fields in the valleys below the force of gravity, but this idea has never been acted upon by the Chinese if it ever entered their minds. Small ponds are made adjacent to the fields and the water is pumped from these and the natural water supplies into the rice fields by man-power alone.

MODES OF IRRIGATION.

The water used for irrigation is drawn up from the ponds and water courses by an endless chain or rather an endless rope pump, which is worked by one man or sometimes two men by treading upon a wheel made with a number of radiating arms which causes the wheel to turn upon its axis. A horizontal pole about 5 feet above the shaft is made fast, and the men support themselves by leaning upon this pole by treading the wheel. One end of the box through which the chain draws the

buckets is placed in the water at an angle of about 45 degrees with the pond, river, or canal from whence the water is drawn into the field. The box is open at both ends and is made strong and light. The whole apparatus is easily carried by one man on his shoulders. The faster the man treads the wheel the more water is pumped, and the machine is kept going night and day when water is needed for irrigation. The pump is run very much on the principle of the treadmill so far as the motor power goes, and the water is carried up with the buckets something like wheat is raised in an elevator.

In this province neither horse nor steam power has ever been thought of, and the manner of pumping water it is believed has not changed for many centuries. Water is conducted into the fields which are usually marked off into small compartments according to the number of proprietors by earth embankments, the water filling one after another until all are covered. Horses are never used in this province by the farmers, and in fact are rarely seen here. Everything is carried by human beings on their backs. The vegetable garden flowers and small plants are watered by water carried on the backs of the laboring people—men, women, and children.

IRRIGATION APPLIANCES.

None of the modern appliances for conducting water over the land have as yet found their way into China. No greater nor stronger power than human hands is ever called into requisition, nor is there any likelihood of any innovation to the long-established custom being permitted in this land where farms are so small and labor so cheap.

No farmer will expend money in experiments for irrigation when he can hire a laborer at from \$10 to \$12 per year to keep the time-honored pump in motion. The working classes themselves would strongly oppose the introduction of labor-saving inventions that would take work from them and tend to cut off their employment. The farms are small, less than 1 acre in many cases, but they have been tilled for perhaps thousands of years and by the skillful use of fertilizers and by care and attention to each plant crops are raised that would astonish the owners of rich soil.

THE RIVER MIN.

The River Min runs diagonally through this province, and a few miles above this city it divides into several branches, which, after pursuing separate courses for 15 miles, unite a little above the pagoda anchorage and empty into the Pacific Ocean, 2 miles below. Along the river are numerous small valleys which can be easily irrigated from the river, but the mode of irrigation is rude and simple. The pump is used for the larger fields, and small plants and garden vegetables are watered by water carried on the backs of the laboring people. The everlasting pole on the shoulders of the bearer, with buckets suspended from each end, is rarely out of view. The water is carried in this way in many places a long distance, but no complaint is heard in any quarter.

When the rains cease, water must be supplied to keep alive the growing vegetation so essential to the existence of the people. During a dry season men, women, and children are engaged in carrying water, which is carefully sprinkled over the vegetation and the greatest patience and care are shown in keeping moisture about the plants. In this part of China the rainfall is fairly distributed throughout the

season, but if the rain does not come at the needed time the water buckets are called into requisition to supply the necessary water for the crops.

AREAS IRRIGATED.

There are no means of ascertaining the area of land grown in rice. This seems to be the only product of the soil that necessitates irrigation. There are no statistics available showing the quantity of land under cultivation. As far as observation goes the whole face of the country, excluding the precipitous mountains and running streams, is used either for farming purposes, for residences, or for cemeteries. The water supply is abundant for all purposes in ordinary times. There are numerous rivers, streams, and springs in all parts of the provinces. There are no laws governing the use of water. Custom rules in this as in almost all the affairs of life in China.

JOHN TYLER CAMPBELL,
Consul.

UNITED STATES CONSULATE,
Foo-Chow, August 15, 1889.

PROVINCE OF KIANGSU.

REPORT BY CONSUL JONES, OF CHIN KIANG.

In compliance with the circular letter of instructions of the Department of State on the subject of irrigation, dated May 2, 1889, and received on the 7th instant, I have the honor to inform you that so far as I can learn there never has been any national or governmental system of water distribution in China.

WATER SUPPLY.

There are no reservoirs worthy the name in any part of the country. This province of Kiangsu, as its name signifies, is the province of "rivers and mulberry trees," and is perhaps the best watered section in the Empire. The almost annual inundation caused by the overflow of the Yellow River and the Yang-tse-Kiang fertilizes the submerged low lands of the province and renders unnecessary any artificial means for the cultivation of crops except that of rice, which requires in the early stages of planting and growth a great deal of water.

MODES OF IRRIGATION.

The methods of providing water for the rice and other crops in general, all over the country, are very simple, and are governed by no laws or regulations beyond the local customs of the people. The farms, so called, are rarely over 2 acres in extent, and are separated by ditches or raised pathways. There are no fences and no ranging stock. To provide a water supply for the fields the farmers usually club together and make large pools to receive the rain for common use. It is then, when required, supplied to the fields by pails. Where a natural streamlet exists it is utilized by conducting it through ditches, or bamboo

pipes, to the fields. Sometimes the water is supplied from these stream-lets by the most primitive arrangement of a water wheel worked by treading with the feet.

These are the methods in vogue since the earliest days in this district, and no improvements on them have ever been attempted. In other districts I have seen the water wheel worked by buffaloes.

The rainfall is very uncertain. Usually in May and part of June three are heavy rains, but last year a long-continued drought almost destroyed the whole rice crop of the district.

In reading of the astuteness of the Chinese, and of their reputation generally as to shrewdness and sagacity, one naturally would expect other things of them, but my observation of the working class and the farmers leads me to the conclusion that while they are hard-working and patient, they are a shiftless and hand-to-mouth people.

A. C. JONES,
Consul.

UNITED STATES CONSULATE,
Chin Kiang, August 17, 1889.

SHANGHAI.

REPORT BY CONSUL-GENERAL KENNEDY.

Ricefields are usually flooded from rivers, streams, and canals.

There is no system of storage of water for irrigation.

All irrigation throughout this section of China (if flooding ricefields may be called irrigation) is carried on by individuals. No further information under this heading obtainable.

The present means of pumping water from streams into fields has been practiced in China from time immemorial.

From Mr. G. James Morrison, an English civil engineer, who had much experience in China, I learn that from observation made during extensive journeys in the interior of this country he has seen no other means of irrigation than the system of pumping from streams directly into the fields, save the more laborious method he saw in the northern sections of China of lifting water in buckets and throwing it over the bank by hand.

On the island of Formosa he saw a more extensive system of irrigation, the water being conducted down the hills for some distance. From Mr. John Fryer, a distinguished sinologue, to whom I applied for assistance in making this report, and who obtained his information from Chinese sources, I learn that in northern Shau-si an arid tract of land has been reclaimed by irrigation. The information is so meager that I merely mention it. In many sections of China there is at the present day extensive tracts of arid land and no attempts are made to reclaim them.

J. D. KENNEDY,
Consul-General.

UNITED STATES CONSULATE-GENERAL,
Shanghai, July 26, 1889.

PHILIPPINE ISLANDS.

REPORT BY CONSUL WEBB, OF MANILLA.

Owing to the numerous streams that rise in the mountainous districts and flow through the lowlands to the sea, as well as to the copious rains, which will average 100 inches during the year, irrigation is seldom necessary in the Philippine archipelago. When it is resorted to, the most primitive methods are followed. If the rainy season commences later than usual, the rice lands are sometimes irrigated by damming the mountain streams and turning the water over the paddy-fields through small channels and in some cases the very old-fashioned chain-bucket windlass is used. This is a simple contrivance, composed of a number of small water-tight boxes, formed into an endless chain by means of stout rope or leather bands, which run over a roller anchored in a river or creek, and a windlass on the bank turned by hand or cattle power. This is also used in some cases during the dry season on the lands where "zacate" or swamp grass, which is fed to horses and cattle instead of hay, is raised.

On the lowlands near the coast, where the river and creeks rise and fall with the ocean tide, sluice ways and gates are sometimes used to flood the zacate lands during the dry season. These fields are seldom more than an acre or two in extent, and a comparatively small quantity of water is needed to flood them. The sluice way is usually about 1 foot or 18 inches square, and when the tide rises the gate is left open until the required amount of water has entered, when it is closed, and remains so until more water is needed.

On an estate belonging to the Dominican Fathers, between Calamba and Bman, and on another owned by the Augustinian Fathers, near San Francisco de Malabon, both situated on this island (Luzon), some irrigation is done during the dry season by turning aside the mountain streams on the zacate land, and near Carite, about 27 miles northwest of Manilla, a small stream is conducted through an iron pipe for about 100 yards for the purpose of irrigating the paddy and zacate fields when water is needed. As a rule, however, the only irrigation received by the ricefields is from the rainfall. The rice is planted about the commencement of the rainy season and is harvested shortly after the opening of the dry season, which seldom continues more than three months. The atmosphere is always moist at night, and heavy dews keep the earth damp and prevent the vegetation from drying up.

There is no portion of the archipelago where irrigation is conducted on an extensive scale, and no means are known here by which the total area irrigated can be ascertained. All the irrigation is done on small patches of land and at private expense.

There are no storage works nor any general system of water distribution for irrigation. The Spanish water laws are in force for the government of the water supply used for household and street-sprinkling purposes in Manilla; but among the general laws there are none upon the subject of irrigation.

ALEX. R. WEBB,
Consul,

UNITED STATES CONSULATE,
Manilla, Philippine Islands, August 21, 1889.

SIAM.

REPORT BY CONSUL-GENERAL CHILD, OF BANGKOK.

Area irrigated.—About one-half of the country is under cultivation, and of this portion fully four-fifths is under irrigation. Rice is the staple, consisting of two kinds, *na suan*, or garden rice, which is transplanted, and the second grade, *na muang*, or field rice. It is estimated that about 10,143,800 piculs (1 picul=133½ pounds) are annually grown in Siam.

Water supply.—Water is supplied to the fields by means of canals, which branch out from the rivers in all directions.

Mode of irrigation.—The water is conducted into the fields by small canals and ditches. The fields are divided off into *ris*, containing about one-third of an acre. Around the four sides of each *ri* an embankment is thrown up, about 2 feet in height, with an inlet, to allow the water to each *ri*, in turn, until the whole number of *ris* is full. There are no published works upon irrigation.

Water distribution.—This system is governed by laws and customs. There is no duty upon the water, but if the land is Government property there is an annual rental in the form of a tax of 28 cents per *ri*, which includes the use of the water.

The large canals are built at the expense of the general Government, but the small canals leading to the fields must be dug by the individual.

Climate.—The climate is tropical with a wet and dry season. The average annual rainfall is 67.04 inches.

Antiquity of irrigation.—The system of irrigation has been in use from time immemorial and is maintained partly by public and partly by private expense.

JACOB T. CHILD,
Consul-General.

U. S. CONSULATE-GENERAL,
Bangkok, August, 1889.

H. Ex. 45—24

AUSTRALASIA.

NEW SOUTH WALES.

FIRST REPORT BY CONSUL GRIFFIN, OF SYDNEY.

INTRODUCTORY.

There is perhaps no question that has attracted so much general attention throughout New South Wales and the other Australian colonies as that of irrigation and the reclamation thereby of arid lands. Royal commissions have been appointed in the colonies for the purpose of conducting inquiries in regard to the best means for distribution and conservation of water. The peculiar physical formation of this great island continent, as shown in the absence of lofty snow-clad ranges of mountains and great rivers, has added an element of difficulty to the inquiries of the commissions.

In my report entitled "Irrigation," transmitted to the Department of State in 1887, I endeavored to summarize the results of the New South Wales water commission inquiry. My report was republished by the government of this colony in book form, and a copy will be found along with the publications I send herewith, under separate cover, a detailed list of which will be found at the end of this report. Since that date the commission has made a final report and a copy of this is also forwarded in the same manner.

It will be seen from the final report that a considerable portion is taken up with a discussion of the various plans proposed for the utilization of the waters of the rivers Murray and Darling. The following are the conclusions at which the commission arrived as the result of their investigations:

1. That on water conservation mainly depend the prosperity and the development of the whole extent of the central and western divisions of this colony, and that, though less required in the eastern division, it will add in many places there also in an important degree to the productiveness, and therefore to the value of the land.

2. That as the landholders, as a general rule, are quite equal to the task of providing sufficient water for the stock which the land can carry under present conditions, government works for supplying water to stock are required only on a limited scale, and generally only on traveling stock routes.

3. That the great object of water conservation in this colony, and particularly in the country west of the dividing range, is for irrigation.

4. That the purposes for which irrigation is chiefly required are (1) to provide fodder and grain for horses, cattle, and stud sheep; (2) to afford supplies to be kept in reserve for saving stock of all kinds in bad seasons; (3) to produce fruit, vegetables, and miscellaneous crops, and (4) to increase generally the productive powers of the land.

5. That any well-considered and properly-executed project for irrigation in the country west of the dividing range would afford a good direct return on the capital invested, and would be a distinct benefit to the colony at large.

6. That legislation on the subject of water rights is a matter of pressing necessity, both to protect the rights of the state and to foster and encourage local and private enterprise.

The severe droughts in Australia, recurring periodically, constitute the most serious difficulty against which the people have to contend.

AREAS IRRIGATED.

Irrigation works in New South Wales have only been carried out on a very small scale by private enterprise—by the squatter, a term applied to the occupier of land in Australia—to provide fodder for working and stud stock, and by the culturist for orchards, vineries, and gardens. I am informed by Mr. A. Pepys Wood, C. E., that no attempt has been made to irrigate agricultural holdings as such. The efforts, however, that have been made, limited as is their scope, have been found valuable, not only to the parties directly concerned, but to the public, as showing the wonderful results to be obtained from the soil and climate of the western districts especially when a certain supply of water is available for watering. Where this supply has been constant, the results are said to have amply repaid the owners and to prove the large profits to be derived from such works if carried out judiciously on a large scale.

The area of irrigated land in New South Wales is at present so small as to be scarcely worth taking into consideration. It is true enough that a few individuals have irrigated portions of their land at their own expense, but the absence of any well-defined laws on riparian rights goes far to prevent the people from utilizing the surplus waters of the various rivers and creeks. The main dependence of the Australians thus far for their water supply has been on dams, tanks, and wells.

In the Lachlan district a number of farmers have practiced irrigation on a small scale. Mr. T. Towser erected a pump about a mile from Forbes, where there is a bend in the Lachlan River. The plant cost about £600 (\$2,920). The plant consists of a six horse-power engine, a 5-inch centrifugal pump, and 75 feet of piping. The pump lifts the water to a height of 38 feet and has power to bring up 2,500 gallons of water per hour. Mr. Towser, during the drought of 1888, irrigated 12 acres of vines and fruit trees. He flooded the land four times. To water half an acre of land necessitated the use of the pump 9 hours, and he estimated that the 12 acres absorbed 2,600,000 gallons of water. Mr. Towser, speaking of his experiment, said:

I could hardly get props enough to keep my trees from breaking down under the very heavy load of fruit, while other orchards, not irrigated, in the district, yielded a very small quantity of fruit.

The Lachlan soil, with the help of irrigation, will grow the finest fruit in the southern hemisphere. The fruits produced are numerous and include many varieties of oranges, lemons, citrons, pears, peaches, apricots, nectarines, quinces, figs, loquots, grapes, and strawberries. The fruit, which had to be sent a long distance to market, is described as unsurpassed in quality, and notwithstanding the high cost of freight and poor facilities for handling it, realized a good profit.

It is proposed to reduce the cost of irrigation on this property by using a 10-inch instead of a 7-inch pump. Irrigation is used in the same district by the Messrs. Eadles & Co., who have a 9-inch pump for irrigating about 800 acres of grass land suitable for high-class stock, also a 7-inch pump is used for a smaller tract. Both pieces of land have carried eight to ten sheep to the acre, while other stock farms not irrigated were literally ruined by the drought. It may be well to mention that Forbes is a town on the river Lachlan, 250 miles west of Sydney. It has a population of about 3,000 inhabitants, and it is rapidly becoming

ing a center for the trade of a large section of the country around. The town is supplied with water filtered from the Lachlan, laid on in pipes at a considerable cost. The district contains about 10,000 inhabitants, and carries 1,000,000 sheep, 10,000 horses, 5,000 cattle, and 2,000 pigs. In 1 year 8,315 acres were planted in wheat and produced 100,519 bushels.

Mr. Gatenby, about 25 miles from Forbes, irrigated, in 1888, 90 acres of land, which was laid down under grass, lucerne, maize, and orchard. He used a 6-inch pump, and he estimates the cost of irrigation at £2 (\$9.73) per acre. Mr. Gatenby stated that with a larger pump he could reduce the cost to about 10s. (\$2.43) per acre. He found that lucerne only required half the quantity of water necessary for ordinary grass. His grass land, which was watered once a month, carried 8 sheep to the acre and his maize land produced 100 bushels to the acre.

I learn from the third and final report of the royal commission on the conservation of water in New South Wales that at Windbar 7 acres yielded 30 tons of lucern hay per annum, under irrigation, at a cost of £3 (\$14.60) per ton, during a drought when chaff delivered cost £23 (\$111.93) per ton. It was estimated that the experiment with irrigation on this property resulted in a saving of £1,000 (\$4,866) in the year. Again, it is stated, that at Tapio 18 sheep to the acre were maintained in splendid condition on a patch of 22 acres of irrigated land, while on the surrounding country, 13 acres barely sufficed to keep one sheep alive; and further, Mr. N. Sadlier, of Albemarle, stated that on an area of 3 miles square, irrigated by the flow of flood waters over low-lying land, he kept 8,000 sheep in the middle of summer and had a good lambing, while the same land, when not irrigated, did not carry 1,200 sheep. The only difficulties which seemed to present themselves were in regard to maintaining a permanent supply in the river to make irrigation possible during the time most needed—a prolonged drought—and the want of practical knowledge to employ the methods of irrigation.

It will be well enough to mention here that the farmers who have tried irrigation are highly gratified with the results, and in most cases their profits have doubled and trebled, more particularly where the irrigation was used on the natural grasses of the country and with lucern, maize, and sorghum.

I could give many instances where irrigation has been adopted with unvarying success, but the areas are mostly small, probably not exceeding a total of 50,000 acres. In the colony of Victoria, however, very large areas are being rapidly placed under irrigation.

WATER SUPPLY.

The sources of supply of water for irrigation are from rivers, creeks, tanks, and wells. The shortage of water supply extends over such vast areas of country as to be a source of astonishment that no well-directed effort has been made to conserve, at least, a portion of the supply falling during the tropical rains, especially in the northern territory. With reference to the works situated on the rivers, the requisite supply of water has been obtained by pumping. For this work the centrifugal pump is generally used, though in some cases, such as for orchard and garden irrigation, direct acting pumps or the "Blake" or "special" type are used. It is said that none of the western rivers, except the Murray, can be relied on for irrigating large areas, unless works be constructed to impound an artificial supply; certainly, with some rivers, such as the Namoi, the supply in long-continued dry seasons is even inadequate for the small areas being dealt with at the present time.

The discoveries of subterranean fresh water north of the Darling River, and the immense supply being obtained from some of the artesian bores, point to a near development of irrigation on a more or less extended basins in that region. In the country south of the Darling, the water in nearly all the wells that have been sunk is said to be brackish, which together with the mineral matter contained in it, is unsuitable for irrigation; were this not the case, the depth (averaging 100 feet) would preclude its use for this purpose, except when drawn by windmills, as fuel for motive power, in most places where these wells are, is reported to be scarce and expensive. It remains to be proved by boring whether at a greater depth an artesian supply of fresh water can be obtained, but as the geological formation is entirely distinct from that north of the Darling, it is said to be very doubtful if the same results will follow deep boring.

I have visited a property on Oxly Creek, Queensland, where water strongly impregnated with salt was used for irrigating the soil for growing lucern. The owner of the land was gratified with the benefits of such irrigation, and he held the opinion that many of the salt lakes in Australia would not be looked upon as a misfortune in the future. It was, however, pointed out to him that a continuation of the use of saline water must sooner or later result in the destruction of his lucern crop. The apparent benefit from the use of salt water was apparent for the reason that lucern, to a very large degree, neutralizes salt in the soil. This has often been remarked in the alfalfa (lucern) fields of California, and farmers account for the fine crops of alfalfa in southern California to the alkaline soil there. It is possible that on the high, dry banks of a river where the soil is deep and good and with abundant natural drainage that saline water might be pumped on lucern fields for a number of seasons without materially injuring the soil. Of course, natural conditions would have to be taken into consideration; as, for instance, in the case of the land to which I have lately referred, where the subsoil is thoroughly washed over by the heavy tropical rains.

Mr. H. C. Russell, Government astronomer, who has since his arrival in the colony, in 1870, devoted great attention to water supply, is very decided in the opinion that there is an abundant supply of underground water in the western districts of New South Wales. Many theories are advanced as to its origin. Some attribute it to a flow of water from the lofty mountains of New Guinea. When Mr. Russell pointed out, about 10 years ago, the remarkable relations existing between rainfall and the rivers of the West, he was told that his statements could not be true. No rain that fell would wet the ground 18 inches deep, much less afford water for underground supplies. With equal confidence it was asserted that the water which did penetrate into the ground was all dried out of it by evaporation; and further, that the greater part of the Darling River basin was so flat that the water would not flow, and the rain, therefore, did not and could not find its way into the river. Mr. Russell determined to await the results of several years of patient investigation before speaking again. With regard to the first objection, he has affirmed that in heavy rains water reached the Darling from the flat country. Evidence as to this fact was found in the rain storm during 1885. In regard to the water from the mountains of New Guinea, he said that even admitting the theory, the area was insufficient. He did not think the water which flows into the Darling passed into the ground, although it was in evidence before the royal commission that parts of

the Darling River basin were exceedingly porous, and allowed the water to sink down freely.

It is the opinion that irrigation in most parts of this colony from tanks is practically impossible, as water conserved in excavated reservoirs would cost about 6 shillings (\$1.46) per 1,000 gallons, a price practically prohibitive. The future of irrigation seems to be largely dependent on the storage of some portion of the flood waters now running to waste, and this can not be effected by expensive works confining such storage waters to the river channels, which under the most favorable conditions would only provide for watering a narrow belt on either side of the river channels, but must be effected by diverting and storing the water in the basins or lakes that nature has formed and into artificial basins or reservoirs constructed, as in America and other countries, among the hills, from whence it could be distributed by gravitation.

MODES OF IRRIGATION.

As already stated, irrigation in New South Wales has hitherto been confined to lands bordering on or adjacent to one or other of the rivers, and no works have been undertaken to increase or regulate the supply. Where the country is suitable the distribution is effected by channels or ditches laid out so as to conform to the features of the ground and of sizes proportionate to the duty they may be required to perform. Pumping water for irrigation is effected by Tangee centrifugal pumps, sometimes by windmills. The water is pumped up into storage tanks of iron or brick and then run off by gravity onto the land to be irrigated, in pipes. This method is, I think, peculiar to Australia; I have never observed it in California, or, indeed, in any other part of the United States with which I am acquainted. In portions of the country where the rainfall is tropical and the soil becomes so dry that every drop of water is precious, tanks and pumps appear to work well, as there is no waste from soakage, evaporation, or capillary attraction. The expense attendant on the above method renders its adoption on a large scale too costly. Orchards and the paddocks around many homesteads are, however, irrigated in this manner.

On the Torrence River, in South Australia, one of the farmers uses a pump with a 4-horse-power engine, and the water is pumped to a height of 35 feet into a square brick tank 10 feet long, 5 feet wide, and 2½ feet deep. More than half the tank is below the surface of the ground. The water when needed is distributed through 2-inch pipes sunk under ground and laid in different directions. At intervals of from 40 to 50 feet standpipes communicate with the surface, and being furnished with stopcocks, the water is turned on or off at pleasure. From the standpipes canvas hose can be adjusted and laid onto the particular spots where the water is required. To facilitate the operation shallow trenches are scooped out near the trees requiring to be watered, and the water is led from one depression to another when the lengths of hose are insufficient. At Emu Plains an extensive orangery is supplied with water in a somewhat similar manner, but here the water is received out of a well about 30 feet deep. The Tangee pump is placed 20 feet above the water and forces it into a number of 400-gallon iron tanks arranged on trestle work. One thousand gallons of water are drawn from this well per hour. On the Nepean River a farmer has an irrigation plant which is worked by 6-horse-power Tangee engine, and the lift of water is 23 feet, from thence it is forced a distance of 850 feet to the storage tanks. The cost of the engine was £110 (\$535) and

the piping £50 (\$243.) The water flows from the tanks by gravity, open furrows are used. In the Riverine district, about Deniliquin, 481 miles southwest of Sydney, where the summer winds are very hot, fruit trees are kept in full bearing by mulching, *i. e.*, spreading litter, whether leaves or other matter, around the butts of the trees. Trenches 4 or 5 inches deep are opened in the soil about 5 or 6 feet from the trees; water is let into the trenches when required. It is said to pay to adopt these means even when the water has to be carted a considerable distance. The average rainfall in this district is only about 16 inches per annum, but nevertheless fruit is very profitably grown.

The success attending artesian well-boring in various parts of Australia led to an investigation of the subject by Mr. W. Anderson, geological surveyor of New South Wales, and I learn from his report that the Lower Cretaceous formation in which artesian water is known to occur extends over a vast area in the eastern half of the Australian continent, occupying the greater part of the interior of Queensland, a large portion of central and south Australia, and the northwestern plains of New South Wales. The southern extension of the cretaceous-tertiary formation occupies a considerable area to the north of the River Darling in the neighborhood of Bourke. Mr. Anderson says it is astonishing that, while this formation has been known for many years, pastoralists on the northern plains did not until recently realize the fact that they have beneath them an invaluable supply of water. He does not recommend boring for water where Silurian slates occur, for the reason that all the Silurian rocks of the district have a general strike of E. 20° N., and stand nearly vertical, therefore they can not possibly hold water in any abundance, and where Silurian formations occur there is always a thinning of the Cretaceous beds. The principles which govern the location of water in the deep-seated beds of the formation, such as the Cretaceous, and its subsequent rising to the surface as artesian water when tapped, are gravitation and the fact that a confined and continuous flow of water must rise to the level of its hydraulic grade. Mr. Anderson directs attention to five positions in which water may be found in the flat western country.

- (1) In the Cretaceous formation itself;
- (2) Between the Cretaceous formation and the Silurian bed-rock on which it rests;
- (3) In the silted up Pleistocene river channels;
- (4) In the immediate neighborhood of the present water courses;
- (5) In the superficial portions of granite, as at Byrock.

A geological map prepared by Mr. C. S. Wilkinson, F. G. S., in charge of the geological survey of this colony, shows the portions of New South Wales where water may be looked for with success.

The water in most of the wells that have recently been sunk is in quantity sufficient to indicate a permanent flow. Such water is used for irrigation by gravity at very little cost.

WATER DISTRIBUTION.

All irrigation works in New South Wales have hitherto been carried out by private enterprise; each owner appears to be a law unto himself, and so long as he does not interfere with his neighbors' water rights are subject to neither rules, regulations, or customs. In Victoria there is an irrigation act, and the necessity for passing a similar act in this colony is urged very strongly both by press and people.

It would be very difficult to form anything like a just estimate of the quantity of water used per acre in New South Wales. The consump-

tion of water on the river Murray, which is the boundary between the colonies of New South Wales and Victoria for farms in Victorian territory, and which cover a large area, is, however, very considerable.

The peculiar river system of Australia has been explained in my published report on irrigation, and I will not now refer to it further than to say that the Murray is the most important river in Australia, and together with its tributaries drains an area of 27,000 square miles. The Murray is navigable for boats of light draft for a distance of 1,700 miles from its mouth. In making its way towards the ocean it passes through a considerable portion of the colonies of Victoria and South Australia. New South Wales, although by her constitution received from Great Britain entitled to the control of the river, has taken no effective steps to utilize its waters for the purposes of irrigation. Both the other colonies have practically taken possession of the water course, and I learn from a report just submitted to the New South Wales parliament by Mr. J. E. F. Coyle, C. E., who has investigated the condition of the Murray, its navigation, and uses of water for irrigation, that out of 143 steamers engaged in the river trade, 67 are owned in Victoria, 55 in South Australia, and only 21 in New South Wales. Mr. Coyle states that the other two colonies have ignored New South Wales not only in regard to the trade on the river, but as to the use of the water for various irrigation schemes.

A number of wharves have been erected on the Victorian side by the government there, together with sheds, plants of machinery, and other works which Mr. Coyle considers inconsistent with the ownership of the Murray by the colony of New South Wales. Since 1886, when the Victorian act authorizing the construction of works on the Murray for irrigation was passed into law, as many as 63 different water interests have come into force for irrigation purposes, and the quantity of water being now drawn from the river is exciting alarm among the people of New South Wales. These Victorian consumers take from the river in summer 102,000 gallons and in winter 61,800 gallons per twenty-four hours; also 46,579 cubic feet in summer and 161,618 cubic feet per minute in winter.

The Victorian government has employed steamers in clearing the river from snags and other impediments. The government of New South Wales of course does not object to that, and it is scarcely probable that she would claim, in spite of her constitutional rights, a supreme control over all the advantages to be derived from the river; but she will undoubtedly object very seriously to any other colony doing so. The Victorians, however, contend that they are simply using the water that otherwise would be wasted, and besides that they have never been granted the right to use it for an indefinite period, for their government in licensing irrigation works have expressly provided that water can be taken from the Murray only so far as it is in the power of the government to permit.

Sir Henry Parkes, premier of New South Wales, in a powerful speech delivered in parliament lately, pointed out what he deemed an aggression on the part of the Victorian government upon the constitutional rights of New South Wales, and very earnestly urged further legislation upon the subject. The truth is, the question of right to control the waters of the Murray can not be settled by one colony alone, and will probably have to be dealt with at an intercolonial conference at which each of the colonies interested can take part, and an agreement reached by which the benefits of their principal water-way tribute may be shared alike.

CLIMATE, RAINFALL, ETC.

The colony of New South Wales extends through 11 degrees of latitude, it being entered on the parallels 28° 10' and 37° 38' south latitudes, and between the meridians 141° and 153° 37' east longitude. The area embraced within these limits contains 310,938 square miles, or 199,000,000 acres. The climate, extending through so many degrees of latitude, very naturally permits almost any variety, from hot to cold. The northern part of the colony resembles that of the south of Italy, Spain, and Greece, while the southern portion is not wholly unlike that of northern California.

At Kiandra frost and snow prevail for a considerable part of the year, but on the plains of the interior the thermometer rises to 130° above zero, and sometimes there is no rain for 8 months in the year.

The average annual rainfall, according to a recent return supplied by the government astronomer, Mr. H. C. Russell, was 23.68 inches for a period of 15 years, from 1874 to 1888; the lowest average being for 1888, when it was 13.40 inches, and the highest in 1887, when it reached 34.49 inches. Mr. Russell has prepared the following table to show the average rainfall in New South Wales for each year from 1874 to 1888:

Year.	Average rainfall.	Year.	Average rainfall.
	<i>Inches.</i>		<i>Inches.</i>
1874.....	33.40	1883.....	17.06
1875.....	29.38	1884.....	15.28
1876.....	27.66	1885.....	19.48
1877.....	20.48	1886.....	26.04
1878.....	25.05	1887.....	34.49
1879.....	30.75	1888.....	13.40
1880.....	19.93		
1881.....	20.73	15 years' mean.....	23.68
1882.....	20.11		

Mr. Russell states that the drought in 1888 was the most severe ever experienced, but during November and December rain fell and broke up the terribly dry weather.

During December, 3 inches of rain fell at upwards of 200 recording stations, chiefly along the coast line, while the great western plains, which needed the rain most, remained to the end of the year in a state of drought.

Not once during the year did rain enough fall on these plains to make water run on the surface of the ground. On the Maranoa River the four months of winter passed with only .03 inches rain. Even the native trees died for want of water, in some places. In Sydney, the average rainfall for a month is about 4 inches, but over large areas in the west, the rainfall for the whole of 1888 was under that amount. At "Louth" on the Darling, it was 2.47 inches; at Menindie, 2.82 inches. Mr. Russell remarks that living in a moist climate near the sea, it is difficult to realize what such a record means in a dry, windy, hot place. The wonder is that plant or animal can live through it. Then, taking the mean of fifty places, the rainfall for the whole colony was 43 per cent. below the average, and it is noteworthy that the rainfall of 1887 exceeded the average by 42.7 per cent.; so the wettest and driest years on record are side by side showing a difference in rainfall amounting to 85.7 per cent. of the average.

When forwarding some valuable publications, Mr. Russell remarks in his letter to me of 28th September, that, knowing what important

questions could only be answered by statistics about rain, rivers, and evaporation, he began to collect them and to educate the people to keep rain records. In 1870 he found five meteorological stations at work. Now they number nearly 1,000. Records of the heights of the western rivers were begun in 1862 by Government officers, but they were not kept up. In the Annual Rain Reports are to be found every known rainfall record for this colony. Mr. Russell has the control of the rainfall records and he states they are fairly complete for a young country, but the work of carefully gauging the output of the rivers has not yet been commenced by the Government; the records which he gives of the western rivers are the daily levels of the water at each place; the water velocities are not measured because competent officers for that work have not yet been stationed on the rivers. The velocities he has used were determined years since, and are assumed to hold good for the same height of flood for each year. Since 1887, however, officers from Victoria have been systematically measuring the discharge of the river Murray and have, so far, confirmed the results which Mr. Russell had obtained in the way indicated.

ANTIQUITY OF IRRIGATION.

The remarks I have made in this report show that the various modes of irrigation practiced in New South Wales are wholly of recent date.

The maps and publications which the Department of State direct me to obtain for the Select Committee of the Senate on the subject of irrigation are enumerated in the following list:

List of printed documents and maps relating to irrigation and reclamation of arid lands; sources of water supply; systems of water distribution; character of climate, etc., so far as relates to the colony of New South Wales.

1. Royal commission—conservancy of water. First report of the commissioners, 1885.
2. Maps, diagrams, and plans referred to in the above report, 1855.
3. Royal commission—conservation of water. Second report of the commissioners, 1885-'86. (Maps and plans are attached.)
4. Royal commission—conservation of water. Third and final report of the commissioners, 1887.
5. Maps, plans, and diagrams to accompany the above report, 1887.
6. Royal commission—conservation of water. First report of the commissioners, abridged edition, 1886.
7. Royal commission—conservation of water. Third and final report of the commissioners, abridged edition, 1887.
8. New South Wales. Her commerce and resources. By Consul Griffin. Report on irrigation, pages 13 to 21, 1888.
9. Climate of New South Wales. Description, historical, and tabular. By H. C. Russell, B. A. F. R. A. S., Government astronomer of New South Wales, 1877.
10. New South Wales. Physical geography and climate. By H. C. Russell, 1884.
11. The River Darling. The water which should pass through it. By H. C. Russell, 1879.
12. Some facts bearing upon irrigation. By H. C. Russell, 1883.
13. Notes upon the history of floods in the River Darling. By H. C. Russell, 1886.
14. Notes upon floods in Lake George. By H. C. Russell, 1866.
15. The source of the underground water in the western districts. By H. C. Russell, 1889.
16. Notes on the experience of other countries in the administration of their water supply. By H. G. McKinney, C. E., 1887.
17. Rivers of New South Wales. By H. G. McKinney, C. E., 1888.
18. Water supply in the interior of New South Wales. By W. E. Abbott, 1884.
19. Forest destruction in New South Wales and its effects on the flow of water in water courses and on the rainfall. By W. E. Abbott, 1888.
20. On wells in Liverpool plains. By T. K. Abbott, P. M., 1880.
21. Metropolitan water supply. By Mr. James Manning, 1875..

22. Comparison between the Prospect and Kenny Hill schemes, proposing a high-pressure water supply for Sidney. By F. B. Gipps, C. E., 1880.
 23. Importance of a comprehensive scheme of water storage and canalization for the future welfare of New South Wales, 1881.
 24. Tanks and wells of New South Wales. Water supply and irrigation. By A. P. Wood, 1883.
 25. Results of rain, river, and evaporation observations made in New South Wales, 1879 to 1888. By H. C. Russell, F. R. S., Government astronomer of New South Wales, 1879 to 1888.
- Ten parts, 25-1879 to 25-1888.

Additional information, publications, maps, and plans, have been promised me in time for transmission by next mail. I have reason to believe that the whole will form the most complete collection of literature on irrigation and water conservancy ever brought together relating to New South Wales.

G. W. GRIFFIN,
U. S. Consul.

CONSULATE UNITED STATES,
Sydney, October 2, 1889.

DEVELOPMENT OF IRRIGATION IN NEW SOUTH WALES.

REPORT BY CONSUL GRIFFIN, OF SYDNEY.

In May, 1881, a royal commission was appointed by the government of New South Wales to investigate the whole question of the conservation of water throughout the colony, and particularly in the western districts. When that commission entered on its labors I am informed that scarcely anything had been done by the government in this matter, and although a large number of dams and tanks had been made by individuals, the progress of private enterprise in this direction was far from what might be expected in a country with such climatic conditions. It is only fair to state that this backward condition of the colony seems to have been due mainly to the unsatisfactory tenure under which the public lands were held. The land act of 1884 had an important effect in removing ill feeling between different sections of the community in the country districts and in giving greater security to all parties. A general hope is expressed that the land act which was passed during the last session of the colonial parliament, and which will come into operation on the 1st of December, 1889, will prove an important step in stimulating settlement throughout the colony and in encouraging enterprise in the improvement of the land.

I observe that there is special reason to expect extensive development of the resources of the western part of the colony, as important concessions there are made to any crown tenant who successfully bores for artesian water.

The forty-fifth section of the new act provides that upon application for the protection of artesian wells and a deposit of £10 (\$48.67), an area of 10,240 acres in one block on a "resumed area" in the western division may be set apart, of which the lessee or licensee shall become entitled to a lease for a term to be fixed, on approval by the governor, after the discovery of water. The term not to exceed the unexpired term of pastoral lease of leasehold area, and the rent to be at the rate payable for an "occupation license." It is provided that not more than one such area shall be leased under this section in each 64,000 acres, and in no case more than three areas in one and the same "occupation license."

The full text of the section is as follows:

45. Upon application in the prescribed manner (accompanied by a deposit of ten pounds to cover the expenses in dealing therewith) for permission to bore and search for water in any land in the western division, held by the applicant under occupation license or annual lease, the minister may, by notice in the Gazette, set apart an area not exceeding ten thousand two hundred and forty acres in one block on the resumed area. Upon publication of such notice the land therein described shall be held to be temporarily exempt from sale or lease under this or the principal act to other than the applicant, but shall not be withdrawn from the occupation license or annual lease; and within sixty days after such notice the applicant shall commence to bore and search for water on such land, and shall forward to the chairman of the land board by registered letter notice verified by statutory declaration of his having done so; and the work of boring and searching as aforesaid shall be continued until water be found, or until it appear to the minister that the work can not be pursued with reasonable hope of success or profit. Within fourteen days after the discovery of water, the licensee or lessee shall, by registered letter, notify the fact to the chairman of the local land board, and the said licensee or lessee shall, on approval by the governor, become entitled to a lease for such a term as may be determined, not exceeding the unexpired term of the current pastoral lease of the leasehold area of the pastoral holding; and the rental of such area shall be at the rate then payable upon the land held under such occupation license or annual lease. If the applicant shall fail to forward any prescribed notice, or if the minister shall consider that the application has not been made bona fide, or that reasonable efforts have not been or are not being made to discover water, or that any water discovered is not sufficiently permanent, or that the quantity is not sufficiently great, he may withdraw the notice aforesaid, or the governor may cancel the lease, and upon publication in the Gazette of notice of such withdrawal or cancellation, the temporary exemption from sale or lease of such land, and the lease thereof, shall be held to be annulled. Provided that not more than one such area shall be leased under the provision of this section out of each sixty-four thousand acres of an occupation license, and not more than three such areas shall be leased hereunder in respect of one and the same occupation license. Provided further that upon approval of the minister all artesian wells heretofore made may be brought under the provisions of this clause on application within ninety days after the commencement of this act.

The royal commission on the conservation of water pursued its inquiries for 3 years, and during that time published the results of its investigations. It appears that shortly after the commission entered on its duties it appointed, as engineer, Mr. H. G. McKinney, who had obtained extensive and valuable experience on irrigation work in Upper India; having been employed as engineer under the Imperial Government of India, for over 10 years carrying out works connected with the Upper and Lower Ganges Canals; the Eastern Jumna and the Baree Doab Canals. One of the earliest duties which devolved on Mr. McKinney seems to have been to inquire into and examine all the levels taken throughout the colony having any bearing on the question of water conservation. A brief statement of the results of these inquiries will be found in an appendix to the first report of the commission. Some of the more important levels are shown in the map of the river systems and drainage areas, which was published with the same report. This examination of the western river systems first brought to light the somewhat remarkable fact that after the Murrumbidgee and the Murray Rivers emerge to the plain country there is a fall in a southwesterly direction from the former river and in a northwesterly direction from the latter; so that it is possible for the waters of both rivers, without any great difficulty, to be diverted into the Billabong Creek which runs almost midway between them.

I understand that a subject which received prominent notice at the same time, and one of much importance to the colony, is the extent to which effluent creeks can be utilized as distributories for flood water.

In Mr. McKinney's paper on "Rivers of New South Wales," which was read before the Australasian Association for the Advancement of Science in 1888, the subject of effluent creeks was dealt with in detail

and their existence was shown to be the natural outcome of the present conditions of the country. It was pointed out in that paper that the sectional areas of the western rivers diminish as the distance traveled in alluvial plains increases, and that this diminution of the river sections is due to the slow process of "silting-up" which is in progress. The natural outcome of this state of affairs is that the lower parts of the river channels are unequal to the task of carrying off the flood waters, and hence the formation of effluent creeks.

It is said that among the more important illustrations of this "silting-up" are the Yanko Creek and its subeffluent, the Colombo, which assist in discharging the flood waters of the Murrumbidgee River, the Willandra and Marowie Creeks occupying a corresponding position in regard to the Lachlan River, and the Cato, Tarrion, and Teryaweynya Creeks, which draw off and distribute a portion of the flood waters of the Darling River. Under instructions from the water conservation commission, Mr. McKinney prepared a project for the improvement of the Yanko Creek. Although this project was only partially carried out, the result achieved has been very important; for while the creek formerly received a supply of water only during high floods, a very moderate rise of the Murrumbidgee River is now sufficient to cause a flow in it. The significance of this has been pointed out to me and will be understood when it is considered that the course of the Yanko Creek is little, if anything, short of 200 miles in length, while that of the Colombo Creek is about 100 miles. The district in which both creeks are situated is remarkably fertile throughout, but badly supplied with water by nature.

The Teryaweynya Creek has been dealt with in a somewhat similar manner by private enterprise, the pastoralists in its neighborhood having at an expenditure of £3,000 (\$14,600) to £4,000 (\$19,466) insured a water frontage to their lands of several hundred miles. It is necessary to explain that both in this case and that of the Yanko and Colombo Creeks, supplies of water are retained in the channels by dams. In the case of the Willandra Creek, or Billabong (a term applied in Australia to a creek, lagoon, or small rivulet running out of one of the larger rivers), a large amount of money was expended by an enterprising pastoralist, but the results were not considered commensurate with the outlay. I am informed that the matter has now been taken up by the government, and a sum has been appropriated for the construction of a weir in the Lachlan River to give a supply to the Willandra Creek during every moderate rise of that river.

The number of dams constructed on creeks and rivers in the western division of New South Wales is surprising when the unsatisfactory state of the law is considered. The condition and results of the law on this point are very clearly set forth in Mr. McKinney's memorandum on "Irrigation in the Riverina," which has been published as an appendix to the third and final report of the water conservation commission. It is there stated that—

As a means of stifling private enterprise, by preventing the utilization of the natural water supply of the country, the British law of riparian rights could scarcely be excelled. For instances of the operation of this monstrous law it is only necessary to look back on the records of dams which have been constructed and guarded by armed men; of other dams which, after construction in this way by one armed mob, have been cut through by another; of many cases where dams were needful, but were not built through fear of litigation, and of the purchase of extensive pumping plant which frequently lay idle for the same reason.

From the utterances of politicians it appears that the present government of New South Wales is pledged to introduce a bill dealing

with water conservation and riparian rights, a measure which will doubtless soon remedy the existing unsatisfactory state of affairs should it become law.

Since the expiration of the water conservation commission Mr. McKinney, as engineer for water conservation under the mines bureau, has had preliminary surveys made throughout the district lying between the Murrumbidgee and Murray Rivers, and though, as I am informed, no official reports of the result have been published it is generally understood that these results are satisfactory and in the main bear out the estimates made by the water commission. I learn that as yet little has been done to carry out the several projects for works for water conservation and irrigation specially recommended by the water conservation commission and which were described in detail and plans illustrating them supplied by the commission. Among the proposals was one for utilizing the water supply in the Murrumbidgee and included the adaptation of Lake Urana, a great natural depression about 17,000 acres in extent, as a storage reservoir. However, the commencement of surveys in connection with the utilization of the waters of the Darling, Lachlan, Macquarie, Namoi, and Gwydir Rivers has been authorized, and the work is to be proceeded with at once. An act appropriating £75,600 (\$367,900) for the purposes of irrigation works has been passed this year.

A paper on "Irrigation in its relation to the pastoral industry of New South Wales" was read before the Royal Society in Sydney on 4th of September last. The Royal Society considered this paper of so much importance that a special recommendation was made to the Government that copies should be distributed throughout the colony gratis, and this proposal it seems has been adopted. Hitherto it has generally been assumed that irrigation would benefit only agricultural and horticultural products, and as the market for such produce was likely to be limited for some time a widespread impression prevailed that irrigation was a question for the distant future. The paper referred to will have an important effect in removing this impression.

The following figures speak for themselves :

Number of sheep in New South Wales on December 31—

1886.....	39, 169, 000
1887.....	46, 965, 152
1888.....	46, 503, 469

The year 1887 was a good one for pastoralists; the year 1888 was unfavorable. Inspection of the figures shows that the number of sheep at the end of 1888 was about 10,000,000 less than if the rate of increase of the year 1887 had been maintained; in fact, instead of an increase of that amount we find that there was a decrease of nearly 500,000. Some idea of the proportion carried off by starvation and thirst may be conveyed by the statement of a writer in one of the Sydney newspapers, who declares from personal knowledge that on one station 60,000 sheep were lost in this way, during 1888, out of 120,000, and on another station 80,000 out of 150,000. The same writer estimates that the number of lambs shorn this season will be 2,000,000 less than last year, on account of the drought, and that for the same reason the wool throughout the colony, north and west of the Lachlan River, will be inferior in quality. The practicability of preventing in an important degree, by irrigation, the recurrence of such losses is not a matter of theory or of opinion but an ascertained fact.

Making provision for the supply of water for the use of live stock traveling to market or for change of pasturage in time of drought is a matter of great importance. Besides the necessity of providing for the live stock of this colony when traveling the multitudes of sheep and cattle passing from Queensland to the markets of New South Wales and Victoria have also to be considered; but the greatest strain on the resources of the public watering places appears to occur in dry seasons, when the pasturage is insufficient and the sheep and cattle have to be removed to other pastures. Generally speaking, the hills and high table-lands immediately west of the main dividing range have a fair amount of rainfall and consequently good pasturage. The effect of this is that in dry seasons sheep are brought from the western plains to these hills and table-lands in hundreds of thousands. This emigration of the live stock always entails considerable risk and frequently results in heavy losses. In the paper already referred to, entitled "Irrigation in its relation to the pastoral industry," the extended adoption of irrigation to prevent these losses is ably advocated, and Mr. J. W. Boulton, a qualified government inspector of stock, states that so far as stock-carrying capacity is concerned purely pastoral districts differ widely, the greater area being classed as poor; but this fact is not due to inferiority of soil, but to the uncertainty of the seasons and the scantiness of rainfall. He states the fertility of the soil to be remarkable, and instances land on the Lower Darling River, where, by actual experiment, 10 acres in its natural state could scarcely support 1 sheep, when the same land had been irrigated and laid down in lucerne 1 acre supported more than 20 sheep.

A memorandum on the necessity for public watering places for live stock, prepared for me by the mines bureau, deals fully with the history of the formation of these places, and it is accompanied by copies of the yearly reports of the officers who are charged with the duty of boring for water. With this memorandum will be found the latest maps which have been published in this colony. The first of these maps is important as indicating the area of the arid parts of the colony where, on the authority of the government geologist, water may be expected to be found by boring. Another of the maps shows the latest information with regard to geological formations; and a third, which has not as yet been issued to the public, exhibits the territorial divisions, the pastoral and agricultural areas, live stock routes, tanks, wells, and trucking stations, together with the railways and telegraph lines.

A map to show the water-supply arrangements for the colony of Victoria is added to the collection.

The following weekly return will serve to exemplify the action taken by the government to afford pastoralists every knowledge as to places where live stock can be supplied with water and feed when traveling through arid parts of the colony to market or to obtain fresh pasturage:

PUBLIC WATERING PLACES.

DEPARTMENT OF MINES,
PUBLIC WATERING PLACES,
Sydney, October 22, 1889.

Weekly return of depth of water and state of pasture in the immediate neighborhood, and estimated rainfall at public watering places on the various routes in the colony.

[The lines in italics indicate the public watering places which have been notified in the Government Gazette. The tanks in capitals indicate the public watering places which are leased.]

Road.	Watering place.	No.	Depth of water.	Esti- mated rainfall.	Condition of pasture.
			<i>Ft. In.</i>	<i>Inches.</i>	
Albury to Walbundrie	JINDERBA TANK	141	17 6		Good.
Albury to Doodie-Cooma	WALLA WALLA TANK	137	18 0	.20	Do.
Wagga to Euabalong	Harman's Tank	80	14 6	.35	Do.
Whitton to Euabalong	<i>Waterman's Tank</i>	87	13 2	.87	Very good.
Wagga to Junee	Wallace Town Dam	143	9 0	.15	Do.
Junee to Temora	JUNEE DAM	144	10 0	.15	Do.
Do.	<i>Hurley's Dam</i>	145	8 0	.15	Do.
Corowa to Walbundrie	CARSON'S SWAMP TANK	138	18 9	.12	Fair.
Howlong to Walla Walla	HOVELL'S DAM	146	14 0		Good.
Howlong to Gregory	<i>Brooklesby Tank</i>	140	20 8	.10	Very good.
Corowa to Urana	LOWESDALE TANK	139	18 0	.39	Good.
Do.	DAYSDALE TANK	147	18 0		Do.
Jerilderie to Tocumwall	BERRIGAN WELL	41	25 0		None.
Do.	MURRAY HUT WELL	42	9 0	.20	Good.
Jerilderie to Corowa	Myall Plains Dam *	40			
Illabo	Illabo Dam	148	12 0	.15	Very good.
Deniliquin to Hay	PRETTY PINE WELL	43	17 0	.04	Good.
Do.	Wanganilla Well.	44	7 0	.74	Very good.
Do.	<i>Black Swamp Tank</i>	45	18 0	1.15	Do.
Do.	BOOROOBAN TANK	46	18 0	.50	Good.
Do.	16-MILE GUMS TANK	47	14 11	.56	Do.
Hay to Booligal	WOOLDOODL WELL†	48	20 0		Very good.
Do.	ONE-TREE TANK	49	18 0	.05	Good.
Do.	Quondong Tank	50	15 0	.25	Very good.
Booligal to Moesgiel	TOM'S LAKE TANK	51	18 0		Good.
Do.	<i>Jumping Sandhill Well†</i>	52	28 6	.10	Do.
Do.	Polygonum Hut Well†	53	25 0		Very good.
Do.	Moesgiel Tank	54	17 11	.21	Good.
Moesgiel to Paddington	Cowrowra Tank	123	17 3		Fair.
Moesgiel to Ivanhoe	HOLY BOX WELL†	55	30 0	.30	Very good.
Do.	Ivanhoe Tank	56	18 0	.60	Do.
Balranald to Ivanhoe	Penarie Tank, late Dowdians.	149	17 6		Good.
Do.	BOX CREEK TANK	63	20 1	.25	Fair.
Do.	<i>TY TI Tank</i>	61	17 8		Very good.
Do.	YOUHL PLAIN TANK	62	18 2	.30	Good.
Do.	Dulmoreva Well†	60	24 9		Do.
Do.	Clare Tank.	59	15 9		Very good.
Do.	GUNNARAMBY TANK	58	15 4	.15	Good.
Ivanhoe to Wilcannia	Boonooma Tank.	64	1 0	.38	Do.
Do.	Mount Manara Tank.	65	17 6	.46	Very good.
Do.	12-MILE TANK.	66	13 6	.13	Good.
Do.	<i>28-mile tank</i>	67	12 0	.55	Do.
Do.	35-mile Tank	68	15 5	.49	Do.
Do.	48-MILE TANK.	69	6 2	.60	Fair.
Carrathool to Hillston	DRY LAKE WELL.	1	20 6	.40	Good.
Do.	<i>Old Gunbar Well†</i>	2	20 0	.49	Very good.
Do.	CROW'S NEST WELL	3	5 0		Good.
Mount Hope	<i>Mount Hope Tank</i>	8	18 1	.75	Very good.
Hillston to Cobar	ROTO WELL	4	16 8	.71	Good.
Do.	NORTH ROTO WELL	5	4 6	.70	Very good.
Do.	<i>Merri Merriwa Tank</i>	6	18 10		Good.
Do.	<i>Wagga Tank</i>	7	20 0		Do.
Do.	<i>Rock holes Tank</i>	9	17 5	.30	Do.
Do.	<i>Sandy Creek Tank</i>	10	14 8	.67	Do.
Do.	PRIORY TANK	11	16 0	.59	Do.
Do.	SHEARLEYS TANK	12	15 0		Do.
Do.	BRURA TANK	13	15 6	.30	Do.
Cobar	Cobar Town Tank *	150			
Do.	Cobar Stock Tank	151	12 0	.75	Very good.
Cobar to Louth	<i>Cuttygullyaroo Tank</i>	15	18 0	1	Good.
Do.	BOOROODARBA TANK	16	17 3	.50	Very good.
Do.	KERRIGUNDI TANK	17	17 6	1	Good.
Do.	<i>Mulga Tank</i>	135	8 9	.70	Very good.

* No caretaker.

† Wells to be deepened by boring.

Weekly return of depth of water and state of pasture, etc.—Continued.

Road.	Watering place.	No.	Depth of water.	Estimated rainfall.	Condition of pasture.
			<i>Ft. In.</i>	<i>Inches.</i>	
Cobar to Bourke.....	TINDERRA TANK.....	18	15 6	.10	Fair.
Do.....	NULLAMLT TANK.....	19	16 0	.....	Good.
Do.....	HELMAN'S TANK.....	92	16 6	1.25	Do.
Do.....	CURRAWERRA TANK.....	91	15 0	1.30	Do.
Do.....	CORILLA TANK.....	90	13 0	.....	Fair.
Do.....	TWO WATERHOLES TANK.....	89	14 11	.....	Very good.
Cobar to Nyngan.....	BOOROOMUGGA TANK.....	20	18 6	1	Fair.
Do.....	MURIEL TANK.....	21	12 0	.....	Do.
Do.....	HERMITAGE TANK.....	23	17 4	.45	Good.
Cobar to Wilcannia.....	AMPHITHETRA TANK.....	14	13 6	.60	Do.
Do.....	The Meadows Tank.....	58	18 3	.50	Very good.
Do.....	Barnato Tank.....	169	13 9	.20	Do.
Do.....	Springfield Tank.....	168	17 6	.....	Good.
Parks to Bogan Gates.....	Brolgan Creek Tank.....	152	18 0	1	Fair.
Dubbo to Parkes.....	Tomingley Tank.....	82	18 4	.25	Very good.
Whitton Railway Station to Cudgellico.....	ULONG TANK.....	37	17 4	1.17	Do.
Do.....	MOUNT ELLIOTT TANK.....	36	17 1	.50	Do.
Whitton Railway Station to Cudgellico.....	PULLETOP TANK.....	35	24 0	.....	Good.
Condobolin to Nymagee.....	Moveable Tank.....	34	15 0	.60	Very good.
Do.....	Boona Tank.....	33	17 8	.77	Fair.
Do.....	TINDA TANK.....	32	18 7	.63	Good.
Do.....	Mombi Tank.....	31	4 9	.....	Do.
Do.....	Wicklow Tank.....	30	18 0	.50	Very good.
Do.....	Heloura Tank.....	29	7 10	.50	Do.
Nymagee to Cobar.....	KEIGHAN'S TANK.....	28	11 9	.30	Good.
Nymagee.....	Nymagee Tank *.....	27	15 9	.85	Very good.
Nymagee to Nyngan.....	BABINDA TANK.....	26	17 11	.50	Good.
Do.....	GILGAH TANK.....	25	13 8	.....	Do.
Do.....	THORNDALKE TANK.....	24	12 10	.20	Do.
Wilcannia to Milparinka.....	Brefwood Well.....	71	.....	.....	.....
Do.....	Menamurlee Well.....	72	63 0	.10	Very good.
Do.....	Tarella Tank.....	73	14 7	.12	Good.
Do.....	THE PEAK TANK.....	74	18 0	.....	Do.
Do.....	Murlippa or Maxwell's Tank.....	76	16 10	.....	Do.
Do.....	Milparinka Well *.....	79	73 10	.....	Fair.
Do.....	Coally Waterhole †.....	78	.....	.....	.....
Milparinka to Wampah.....	Warratta Tank.....	80	12 6	.....	Bad.
Bourke to Tibbooburra.....	Tibbooburra Well.....	133	.....	.....	.....
Tibbooburra to Wampah.....	Tibbooburra Well-bore.....	176	57 0	.....	Good.
Wilcannia to Hungerford.....	Seaville's or Cudrilla Tank †.....	122	.....	.....	.....
Do.....	Momba Waterhole †.....	154	.....	.....	.....
Do.....	Peri Springs and Tank †.....	120	.....	.....	.....
Do.....	YANTABANGEE TANK.....	119	16 0	.....	Do.
Do.....	Warramurtee Tank †.....	118	.....	.....	.....
Do.....	Goomboolara Tank.....	117	16 6	.....	Very good.
Bourke to Wanaaring.....	GOONERY ARTESIAN WELL.....	101	5 0	1.7	Good.
Do.....	Tinchehook † (artesian).....	155	.....	.....	.....
Do.....	Kulkine Tank †.....	102	.....	.....	.....
Do.....	Cuttaburra Artesian Well †.....	134	.....	.....	.....
Girilambone.....	GIRILAMBONE TANK.....	22	22 0	1	Do.
Brewarrina, via Gongolgan, to Byrock.....	Bendermere Tank.....	100	15 4	.....	Very good.
Do.....	Mulga tank.....	99	.....	.....	.....
Bourke to Hungerford.....	FORD'S BRIDGE TANK.....	103	14 10	1.90	Fair.
Bourke to Enngonia.....	Kullyba Spring †.....	153	.....	.....	.....
Bourke to Enngonia and Bar- ringun.....	THE LAKE TANK.....	93	18 0	1.60	Do.
Do.....	GRASS-HUT TANK.....	94	15 1	1.75	Do.
Do.....	Couralie Well †.....	95	.....	.....	.....
Enngonia to Brewarrina.....	18 MILE TANK.....	97	20 0	1.25	Good.
Do.....	LEDKNAPPA TANK.....	98	20 0	.42	Do.
Walgett, via Bangate, to Goo- dooga.....	Boro tank.....	114	16 5	1.55	Do.
Do.....	Lightning Ridge Tank.....	115	16 0	1.10	Do.
Do.....	Glendon Tank.....	116	17 0	.....	Do.
Walgett to Wilby Wilby.....	Bunghill Tank.....	112	15 0	1.27	Good.
Do.....	Cumborah Spring †.....	113	.....	.....	.....
Coonamble to Warren.....	BULLAGREEN TANK.....	104	18 6	2.80	Very good.
Pilliga via Baradine to Coona- barabran.....	BARADINE WELL.....	105	53 0	.....	Do.
Do.....	Yarraman Spring †.....	106	.....	.....	.....
Coonabarabran to Gunnedah.....	Mannum Well.....	107	50 4	2.25	Good.
Boggabri to Coolah.....	Tambar Springs.....	167	.....	3.10	Do.
Narrabri to Moree.....	GALATHERA TANK.....	110	18 0	.50	Do.
Do.....	BOGGY CREEK TANK.....	111	17 9	.72	Very good.

* Under trustees.

† No caretaker.

Weekly return of depth of water and state of pasture, etc.—Continued.

Road.	Watering place.	No.	Depth of water.	Estimated rainfall.	Condition of pasture.
			<i>Ft. In.</i>	<i>Inches.</i>	
Moree to Mungindi.....	Bogree Waterholes*	163			
Cowabee to Wagga.....	Coolaman Tank.....	164	20 9	1.35	Very good.
Narrandera to Urana.....	COLOMBO DAM.....	165	10 0		Good.
Silvertown.....	Silvertown Well.....	166	52 0	.23	Do.
Adelaide to Silvertown.....	Rat Hole Tank.....	126	15 10	.15	Very good.
Do.....	Thackaringa Tank.....	127	19 1	.10	Good.
Silvertown to Nickleville.....	DAY DREAM TANK.....	125	19 9		Very good.
Purnamoota.....	Purnamoota Tank.....	124	7 10	.50	Good.
Triangle to Dandaloo.....	DEIRIBONG TANK.....	136	20 0	1	Very good.
Howlong to Albury.....	Horseshoe Lagoon*	142			
Neverthre.....	Neverthre Tank.....	88	14 3	.60	Do.
Forbes to Currajong.....	Newell's Dam*.....	84			
County of Irrara, Parish of Mukudjeroo.....	Mukudjeroo Water Hole*.....	83			
Urana.....	Urana Dam.....	182			Good.
Broken Hill to Silvertown.....	Limestone Bore.....	175	6 2		Very good.
County of Yancowinna, Parish of Mount Gipps.....	Four-Mile Well on Stephens' Creek*	172			
Germananton.....	Germananton Well*.....	177			
Village of Bowning.....	Bowning Well.....	174			
Thuddungara.....	Thuddungara Lagoon.....	171			

* No caretaker.

In course of construction and proposed :

Road.	Watering place.	No.
Balranald to Ivanhoe.....	Willandra Well*.....	57
Barrington.....	Barrington Well-bore.....	96
Wilcannia to Milparinka.....	The Valley Well*.....	81
Do.....	Dry Lake Tank*.....	70
Do.....	J. K. Well*.....	75
Do.....	Cobham Tank.....	77
Wilcannia to Hungerford.....	Copago Tank.....	121
Bourke.....	Well-bore.....	
Bourke to Wanaaring.....	Paka Tank.....	156
Bourke to Hungerford.....	Keribree Creek Weir.....	157
Do.....	Youngarinna Spring Well.....	158
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Enston to Pooncarria.....	4 Well-bores.....	
Menindie to Ivanhoe.....	5 Well-bores.....	
Box Creek to Arumpo.....	1 Well-bore.....	
Grenfell to Cowra.....	1 work.....	
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Deniliquin to Moama.....	The Yellow Waterhole (Well-bore).....	
Narrabri to Moree.....	Tycannah Dam.....	
Deniliquin to Moama.....	1 Well-bore.....	
Coonamble.....	do.....	

* Unfinished.

† Recommended for early construction.

It is said with perfect truth that the discovery of the presence of constant supplies of water in the arid localities where the bores are being sunk will entirely alter the conditions of large areas of the colony, which at certain seasons are almost impassable for live stock and quite uninhabitable for man.

In June last, by direction of the premier of this colony, Sir Henry Parkes, and Mr. J. E. F. Coyle, C. E. (as I have already informed the Department), made an inspection of the state of the Murray River. Another engineer, Mr. D. McMordie, C. E., was directed to inquire into the question as to the amount of water diverted from this great river (forming, as it does, a boundary between the colonies of New South Wales, Victoria, and South Australia) during its progress to the ocean. Mr. McMordie's report has been presented and laid before parliament, and shows what has been done in the colony of Victoria.

Here I desire to give prominence to the fact that it is by enterprise from the United States that the benefits of irrigation in Australia on a large scale have been first practically demonstrated. Nothing had been done by diversion of water from the rivers to prove the advantages of irrigation toward reclamation of the public lands until Messrs. George and W. B. Chaffey, though natives of Canada, arrived from California, where they had derived experience and had successfully carried out irrigation projects. After considerable difficulty they obtained concessions from the government of Victoria enabling them to place an area of 250,000 acres of land at Mildura, on the Murray River, under irri-gable culture. No one who sees the photographs which the Chaffey Company have presented to me for the use of the special committee of the Senate, can doubt the ultimate success of their great undertaking.

In the colony of Queensland, to the north of New South Wales, the government and people are fully alive to the necessity which exists in their semitropical country for irrigation as a means of increasing their wealth and prosperity. The progress of the work in those parts will be seen from the report on "Water Supply in Queensland," by the hydraulic engineer, Mr. J. B. Henderson, C. E.

MAPS AND PUBLICATIONS.

In obedience to the instructions contained in the circular from the Department of State, I have obtained from every available source copies of maps, plans, photographs, publications, and documents—as far as possible in duplicate—and the following list will indicate where each is to be found among the complete set, which I have had bound in fourteen volumes.

AUTHORITIES ON IRRIGATION.

The special committee of the Senate having intimated the "desire to place itself in communication with competent experts and authorities on irrigation," I beg leave to submit the following list:

A.—Underground supply of water:

- C. S. Wilkinson, esq., F. G. S., F. L. S., etc., government geologist of New South Wales, Sydney.
- T. W. E. David, esq., B. A., F. L. S., esq., geological surveyor of New South Wales, Sydney.
- W. J. Slee, esq., mining inspector and superintendent of drills to the government of New South Wales, Sydney.

B.—Irrigation and water supply :

- H. G. McKinney, esq., M. E., member Institute of Civil Engineers, formerly of the irrigation department, Upper India, lately engineer to the Royal Commission on the Conservation of Water, and now engineer for water conservation to the government of New South Wales, Sydney.
- D. McMordie, esq., B. E., member Institute of Civil Engineers, formerly of the irrigation department, Upper India, lately member of the Royal Commission on the Conservation of Water, and now district engineer of sewerage works to the government of New South Wales, Sydney.
- George Gordon, esq., Member Institute of Civil Engineers, formerly chief engineer to the Madras Irrigation Company, lately chief engineer for water supply in Victoria, Melbourne, Victoria.
- J. B. Henderson, esq., Member Institute of Civil Engineers, hydraulic engineer to the government of Queensland, Brisbane, Queensland.
- W. B. Henderson, esq., formerly superintendent of the drill and water-boring department to the government of New South Wales, Sydney.
- F. A. Franklin, esq., Member Institute of Civil Engineers, formerly commissioner for New South Wales at the Calcutta Exhibition, Sydney.
- W. J. Lyne, esq., M. L. A., formerly president of the Royal Commission on the Conservation of Water, Sydney.
- James P. Dowling, esq., Sydney.
- George Mair, esq., Groongal Station, New South Wales.
- F. B. Gipps, esq., C. E., Sydney.
- James Wilson, esq., secretary to the Pastoral and Agricultural Association, of New South Wales, Sydney.

METEOROLOGY IN RELATION TO WATER SUPPLY.

Among the papers on meteorology transmitted with this dispatch will be found a curious and interesting work entitled, "Egeson's weather system of sun-spot causality, being original researches in solar and terrestrial meteorology, by Charles Egeson, weather-map compiler, Sydney observatory." The work was published by Turner, Henderson & Co., Sydney, during the early part of the present year, and it at once attracted general attention throughout these colonies. It is accompanied by diagrams, illustrating the system.

During the last few weeks renewed interest has been created in the work by a prediction made by the author that there would be a drought throughout Australia extending over a period of 3 years from 1890 to 1893.

Mr. Egeson has, within the last year, made several weather forecasts which have been more or less verified. It may be mentioned that in January, 1889, Mr. Egeson predicted decreasing rains during the first quarter of the present year; in March following, increasing rains and break-up of drought; in April, a maximum fall of rain with floods to occur early in May; in June, decreasing rains during July and increasing rains in August. The manner in which the forecasts were realized has inclined not only the public but scientific men to attach importance to the results of these meteorological investigations. The fact must be noted, however, that Mr. Russell, the government astronomer, in reporting on these forecasts says :

I am convinced that neither in the theory propounded nor in the experience we have had so far of its practical application is there anything to justify anyone in supposing that it affords the basis upon which reliable forecasts for months or years in advance can be made.

It is needless to say that Mr. Egeson's prediction of a 3-years' drought has occasioned something like a panic in the community. The pastoral and other interests were becoming so seriously affected by the prediction that Mr. Egeson has been prohibited from publishing his forecasts except with the sanction of the government astronomer. The minister

for education, Hon. J. H. Carruthers, who has the direction of the bureau in which Mr. Egeson is employed, in a minute dated 23d of October, remarks:

Mr. Egeson's weather forecasts have created considerable alarm in the public mind, and to some extent investments of capital in stations and stock has been checked. The vast majority of the public are not sufficiently advanced in meteorological science to be able to follow either the data or the conclusions arrived at, but that knowing that the forecasts came from a Government officer employed by its observatory, and the conclusion arrived at most generally is that forecasts should be treated as having some official weight and authority.

Now, I am compelled, in order to meet such an impression, to invite Mr. Russell to reply to his subordinate officer, and I feel that the efficiency of the Sydney Observatory will be utterly destroyed if a rule is not enforced to prevent a recurrence of such procedure. Mr. Russell alone is the mouthpiece of our astronomical department, and no officer engaged under him has a right to ignore him as the proper channel of publishing matter within the scope of that department, even under the cover of private rights of citizenship. These private rights are to a certain extent suspended when a contract of public employment is entered into. The public interest overrides the private right, and it this case it demands that the responsibility of grave and important predictions emanating from the observatory officials shall rest upon its astronomer alone. As he has that responsibility he must have the safeguarding privilege of checking the statements of his staff.

With purely scientific research on abstract matter, and otherwise in private work, which does not involve the proper functions of the observatory, no inference is intended, or would be countenanced by me, and even in the administering of the rule recently laid down the most liberal consideration compatible with the public interest will be shown to all officials who desire to express their views on observatory work through its recognized head.

Mr. Egeson's weather system and drought predictions, so far as I am able to understand, may be described as follows:

The yearly fluctuations in the rainfall are taken to have relation to a masked cycle which governs all, not as individual years but as periods of several years. The mean value of each natural period has a direct relation to the cycle.

Other elements representing less complete operations of nature are next examined. Thus the frequency of thunderstorms in New South Wales is found to vary in a cycle of 33 years. The winds, at the times of the equinoxes, when the condition of the earth might be expected to show most markedly the operation of law and order, on being analyzed show in the relative frequency of land and sea breezes the same cycle of 33 years.

With these guides the fluctuations of the rains are again examined with the result that in general outline they correspond, and on comparing the constituent parts these are found to repeat themselves every 33 years on the average, though they may be a year or so more or less.

To trace the cause of the 33-years' periodicity the barometric pressures for April, *i. e.* the month when the winds are shown to be so remarkably cyclical, are examined with the result shown on a diagram published by him on page 44 of his weather system, by which it appears that high barometers prevail at times of minimum sun spots, and *vice versa*, and that there is an intensification of maxima of each third cycle, as in 1857 and 1888, as well as an intensification of one of the intermediate minima, as in the years 1870 to 1873, and the result is that a grand cycle of three times eleven years is produced. (In this case it is, for reasons to be presently explained, only 31 years.) This intensification of every third cycle which produces the grand cycle of 33 years, and to which all data of recent years are said to point, was also noted in the early history of New South Wales. Montgomery Martin, the historian, writing in 1836, says:

The seasons appear to undergo a variation every 9 or 10 years, varying, however, in intensity every third series of 30 years.

Researches into the variation of so-called rain periods at Sydney and a number of other stations point to an intimate connection between these and the state of the sun, as shown by sun spots. Other detailed comparisons of variations in the rainfall and sun spots point in the same direction.

This relation, Mr. Egeson states, furnishes the means of forecasting rainfall for months in advance, and the results when put into practice compare favorably with those of daily forecasts.

Regarding forecasts for longer periods for years in advance, the cycles are the guides. But since these are compounds of the 11-year sun-spot cycles, which vary in their fluctuation over long periods of time (the cycles covering the year 1835 to 1878 being abnormal as compared with preceding and following cycles), it follows that one meteorological cycle is not comparable with another unless the condition of the sun is similar. This explains why the intensity and duration of the same meteorological epoch may vary in different cycles, as for instance the 3 years' drought of 1827-1829 was not reproduced as such in the following cycle, and it explains why it should occur in the present cycle.

Calculated upon the basis of an average periodicity of 33 years, Mr. Egeson stated this drought to be an event that might be expected within a few years. But on reopening the question the progress of events pointed to an acceleration of 2 years having taken place, as shown by the high barometers of 1857 and 1888 and the similarity in the distribution of rain in the years 1858 and 1889 as well as other evidence, and the conclusion must be arrived at that the present climatic epoch is only 31 years, from a corresponding phase of the last cycle, and only 64 years from that next preceding, when similar solar variation prevailed. In confirmation of this the climate of the years 1823, 1824, and 1825 correspond with that of 1887, 1888, and 1889, the droughts of 1824 and 1888 being identical. This agreement justifies the expectation of the recurrence of the drought of 1827-1829 in 1891-1893, with its commencement from about the middle of 1890 as in 1826.

The explanation Mr. Egeson attributes to the sun-spots phenomena, in that the last maximum was over 2 years late, while the approaching minimum will have restored the normal by an acceleration. So the rainy seasons of 1887 and 1889, which were accelerated 2 years, must be followed by a corresponding delay in the arrival of the next rainy season, in order that normal conditions may be restored, and this, Mr. Egeson asserts, must mean a protracted drought.

Mr. Egeson's studies in meteorology, carried out during his spare time, procured for him employment as weather-map compiler at the Sydney Observatory on his arrival in Sydney about 5 years ago, and doubtless his observatory work in Australia has led him to the conclusion that we have in fact begun at the wrong end of the investigation by attempting to solve the mystery of the little eddies before ascertaining the state of the stream in which they occur.

Although comparatively a young man, Mr. Egeson has had a varied experience. He followed a sailor's calling for 5 years, and during that time had opportunities for studying the various phases of weather in storm and calm from the coast of Iceland to the most southern limits of Africa. In India he was present during the horrors of famine in 1876-1877 in that country, when on every side men, women, and children lay dying of starvation, a calamity, he states, in a measure due to the short-sighted policy of their fellow-men in neglecting to prepare for a protracted drought. In Ceylon, during a residence of 7 years, he frequently witnessed "the burst of the monsoon," the grandest of all

climatic convulsions. These eastern experiences induced him to investigate the ancient theories and traditions of the natives, who believe in a periodicity of 30 years or thereabouts, and in accordance with which they work their splendid system of irrigation.

G. W. GRIFFIN,
Consul.

CONSULATE UNITED STATES,
Sydney, October 29, 1889.

IRRIGATION IN NEW SOUTH WALES.

[Inclosure in Consul Griffin's report.]

COMMERCIAL, PASTORAL, AND AGRICULTURAL ASSOCIATION
OF NEW SOUTH WALES,
40 Hunter street, Sydney, August 28, 1889.

G. W. GRIFFIN,
U. S. Consul, Sydney:

SIR: I have received from you questions on the subject of irrigation and the reclamation thereby of arid lands, with information that a special committee has been created by the Senate of the United States to investigate the questions involved.

The collection and systematic organization of reports on this subject from all parts of the world, which your consular system affords, can not fail to be of the greatest public utility not only to the United States but to every arid corner of the universe; and it is to be hoped the committee will produce a report on comprehensive scale, which when published will prove of immense benefit to generations yet unborn.

For some time the Commercial, Pastoral, and Agricultural Association of New South Wales has been engaged in noting the steps taken in this colony to deal with the arid lands in her vast interior and in collecting documents showing the great aid afforded by the Royal Society of New South Wales and kindred scientific associations for dealing with the local question, and in contrast with other countries, from more or less unofficial sources. I shall have much pleasure in placing these records at your disposal.

To my mind the question to Australia of water conservation and distribution, the development of underground reservoirs proved to exist, the economical adaptation of such and rainfall observations as will minimize waste from the effects of periods of drought by regulating supply, is as necessary as a mainspring to a watch. Upon the satisfactory evolution of water difficulties depends the future development of this vast island continent, whose very existence a century ago was comparatively unknown.

Of this continent New South Wales embraces a territory of 195,882,012 acres, and her present record of population is only a little over 1,000,000. To the United States our population and occupancy of territory, when compared, must form an insoluble problem, but the key is to be found in the pastoral stage of development in civilization during the nineteenth century as practiced in Australia, and when we compare the numbers of the population actually outside our towns and cities the position will appear more explicable why we can not in the present stage point to existing irrigation and water, conservation works, and irrigable and nonirrigable areas and their results. The works in existence at present are only the outcome of private individual enterprise within freehold limits, and bear no proportion whatever to the exigencies or necessities of the country at large, its rainfall, or river systems.

The mode of land tenure, the centralizing department form of government, and political inability to deal with so extensive a public estate upon a broad and national basis are the true causes of neglect of and inertia towards our progress in this direction. It is from no want of consideration or inability on the part of our best men to grasp the importance of the situation, but from the general *laissez-faire* of our political economy, which provides that all public works in the colony are conducted and controlled by government departments centered in the city of Sydney, not in touch with what might be termed local or district wants, and resenting interference with their prerogative unless under political pressure, a system which ascribes drought and disaster to Providence and fails to use means nature has provided for amelioration.

A more valuable compendium of information from many sources on irrigation in New South Wales than that presented in your consular report to the Department of State, Washington—republished by the New South Wales Government in 1888—does

not exist, nor one more truthfully and fully describing this country, and I would respectfully suggest that that report be laid before the committee of the Senate. You have fairly pointed out the difficulty of riparian rights as they exist at present and the incidence of common law as prohibition to deal with water conservation on a comprehensive scale, and you have cited the opinions of the water-conservancy commission, appointed in 1884. It only now remains to supplement this by reference to their report in 1887, since published.

There have been no water trusts created and no law changing riparian rights in this colony.

The first bill in New South Wales to provide a water trust, a municipality bill for the irrigation of a town common at Wentworth of 21,000 acres, on the New South Wales side of the river Murray, is now before Parliament.

Successive governments have for years past promised a scheme of local or district government which will embrace powers for dealing with water and irrigation by local trusts. Hitherto in this colony the public works for water conservation have been confined to constructing watering stations on the traveling stock routes in arid districts, wells, tanks, and dams.

The Government first recognized the necessity for such in 1869, and in 1888 it would appear, from a statement relating to watering places, one hundred and forty-four in number, that an expenditure of over £270,000 (\$1,313,955) had been made in construction and appliances, their maintenance costing over £25,000 (\$121,663) per annum. These works have no doubt exercised a large and beneficial influence upon our pastoral progress.

I would suggest that you obtain from the Government printer, Sydney, such official documents bearing on the subject as have been printed from time to time.

It only now remains to state that the Government have conducted preliminary steps to carry out a scheme of irrigation and water supply by canals, submitted to the water commission by H. G. McKinney, C. E. Surveys are completed and the engineers are now taking levels for canals near Albury, on the Murray River. The main Albury canal will be 176 miles in length; Jerilderie branch canal, 33 miles, and Suppel branch, 31 miles; a total of 240 miles. The estimated cost of this undertaking is £1,500,000 (\$7,299,750), and the area to be irrigated 570,000 acres.

To water conservation and irrigation as prosecuted in other countries, and especially in India, all our New South Wales and Victorian schemes must appear insignificant; but we are only a young country and a small community anxious to profit by the experience of others, and will gladly benefit by the results of the inquiry being made by the special committee of the United States Senate, embracing as it will consular reports from all countries.

I shall have pleasure in forwarding your inquiries in any way in my power.

JAMES WILSON.

THE MILDURA IRRIGATION SETTLEMENT.

[Inclosure in No. 158, transmitted by Commercial Agent Dawson, of Newcastle.]

A point called Psyche Bend, about 5 miles above the town, is perhaps the principal pumping station in connection with the scheme. This is at the off-take of King's Billabong, a deep, wide water course, several miles in length, which fills when the ordinary floods of the Murray take place. It is to be used for storage purposes and a powerful pumping plant is being provided to fill it rapidly while the river is at a high level. From the storage billabong the water is raised by other pumping plants to channels which are 50 feet and 80 feet above the summer level of the river. The foundations for the pumping plant at Psyche Bend are nearly completed and the works are of a very extensive character. The pumping plant, which will soon be erected, consists of a 1,000-horse-power triple-expansion engine, drawing four centrifugal pumps, capable of sending 120,000 gallons of water per minute a height of 20 feet, the diameter of the pumps being 40 inches. At King's Billabong the pumps have been erected, and on entering the building the visitor is astounded at their magnitude. The engine is a duplicate of that at Psyche Bend and it drives four centrifugal pumps 20 inches in diameter, raising 40,000 gallons per minute into the channel, which is 50 feet above the summer level of the river. A large, substantial brick building, 30 feet high, covers the machinery, and both pumps and building possess the marked characteristic of solidity. These two pumping engines were designed by Mr. George Chaffey, and the larger one is believed to be the biggest direct-action centrifugal in the world applied to irrigation purposes.

At a place called Nichols Point there is another substantial building, containing a 450-horse-power engine, with pumps capable of raising 20,000 gallons per minute from

the 50-foot channel into the 70-foot channel, the same plant also, when required, sending 7,500 gallons per minute into the 80-foot channel. The town and about 2,000 acres are supplied by a 200-horse-power compound engine, working a double-action force pump, which raises 1,000 gallons per minute to a height of 70 feet. A mile lower down the river a similar engine raises water into the 35-foot channel, lifting 30,000 gallons per minute, and still lower down a small direct-action centrifugal supplies Lord Ranfurley's plantation at the rate of 1,000 gallons per minute. The figures given refer to the power of the various pumps and not to the work which they have as yet been called upon to perform. Twelve miles of wrought-iron pipes, from 8 inches to 22 inches in diameter, have been laid, and there have been made about 31 miles of main channels and 25 miles of subsidiary channels. Water has thus been provided for about 30,000 acres of land. There have been 7,000 acres sold, 3,000 acres cleared of mallee scrub and 2,000 acres planted with vines and fruit trees. The Chaffey Brothers have planted, on behalf of purchasers, 250 acres of vines, principally raisin varieties, 425 acres orange trees, 150 acres lemons, 100 acres apricots, 50 acres figs, and 20 acres prunes. The settlers have planted on their own account about 200 acres of vines and fruit trees. There are 600 acres under cereal crops, 30 acres under lucerne, and 200 acres are being prepared for maize. The grain crops look well; the returns obtained from sorghum are astonishing and the growth of all the vine and fruit plantations is surprising. The settlers seem all well satisfied with their prospects and those who gave evidence spoke with warmth of the wonderful growth of vegetation under the conditions of a warm climate, a rich soil, and a sufficient supply of water. The clearing of the mallee, which is done by means of a traction engine and a wire rope, costs from £2 to £4 per acre, and most of the breaking up is also done under contract by the Messrs. Chaffey's steam cultivators. Building operations are being fairly carried on in the town, and the population of the entire settlement is now estimated at 1,200, including 250 men employed by the promoters. The comfortable boats, lit by electric light, make the river trip a very pleasant one. A very enjoyable trip was made by the commission, and all returned with a firm belief in the genuineness of the Mildura enterprise and confidence in its ultimate success.—[*The Argus*.]

HAWAIIAN ISLANDS.

REPORT BY CONSUL-GENERAL SEVERANCE, OF HONOLULU.

Effects of irrigation.—Where irrigation is continuous the product of sugar has increased to an average of 4 tons per acre, while the same lands without irrigation formerly yielded only the average of 2 tons per acre.

Area irrigated.—The area of good cane land is limited; the most reliable estimates do not exceed 90,000 acres; of rice land 7,000 acres, and of land suited for bananas, at present under cultivation, 3,000 acres; total, 100,000 acres. Of the cane land about 45 per cent. is irrigated; the remainder, except for rice land, which is all under irrigation, is subject to the annual rainfall, which is copious on the highlands on the windward or eastern side, while it is limited on the leeward or western side.

Production.—The quantity of sugar produced in the year 1888 was estimated at 120,000 tons, two-thirds of this, of a good light color, polarizing from 86° to 96°, and one-third of the yield polarizing from 76° to 84°, all of which was sold at good figures for refining purposes.

The estimate of rice was 20,000 tons, one-third of which was exported and the remainder consumed here, all of good quality.

Of bananas about 100,000 bunches; 75,000 exported, balance consumed here.

Water supply.—The sources of water supply are from mountain streams, springs, artesian wells, and storage reservoirs. The character of works, distribution, etc., consists of dams and basis by which water is

imponned and then conveyed by wrought-iron and cast-iron pipes, flumes, and open-water leads and ditches at various distances from 5 to 40 miles. This system of distribution is regulated largely by leases from landowners, and by custom and common consent, with sanction of law.

For twelve months' irrigation on the Spreckelsville plantation, on Maui, 566,280 cubic feet were used, equal to 3 inches per acre every week, or say 5.8 cubic feet for 1 pound of sugar produced. This may be a large quantity, as the usual estimate would be 1 cubic foot of water per second to properly irrigate 45 to 65 acres of cane or 30 acres of rice.

Cost of water.—On page 21 of report the highest cost of pumping is estimated at \$3 per acre per month or \$45 per acre per crop. No reliable estimate can be found of cost of water supply distributed by pipes, ditches, flumes, artesian wells, or springs, this would depend on the distance, the means of conveyance, the character of the country, and the flow.

Ownership.—Both private and lease from the Government.

Climate.—The climate is variable, according to elevation; on the leeward or western side, in proximity to the ocean dry; the eastern side generally moist and cool; good soil in the valleys, yielding fair crops.

Rainfall.—Mean rainfall on the island of Oahu from 1867 to 1883 was 62.6 inches (see page 24 of report, inclosed) while the minimum rainfall along the coast exceeds 24 inches, and upon the mountain slopes from 40 to 90 inches, according to elevation; in the Hilo district, on Hawaii, 120 inches.

Antiquity of irrigation.—A system of irrigation has always existed among the Hawaiians throughout the Kingdom, conveying the water from the mountain slopes and springs through the valleys, over hillsides, for the production of their chief article of food, the *Arum esculentum*, or *kalo*, from which *poi* is made. Many of the ancient water leads are still maintained at private expense by the owners or lessees of the land, running from the mountain to the sea.

H. W. SEVERANCE,
Consul-General.

U. S. CONSULATE-GENERAL,
Honolulu, Hawaiian Islands, October 17, 1889.

Water supply for irrigation on the island of Oahu, Hawaiian Islands.

[Inclosure in report of Consul-General Severance.]

HONOLULU, HAWAIIAN ISLANDS, *August 26, 1889.*

B. F. DILLINGHAM, Esq.:

DEAR SIR: The purpose of the invitation extended to us by you to visit the Hawaiian Islands was, as we understand it, to obtain the opinions of engineers qualified by practical experience in hydraulic works as to the water supply available for irrigation in certain portions of the island of Oahu, and the practicability of establishing extensive plantations of sugar cane on the Honouliuli and Kahuku ranches, to be supplied with water for irrigation in accordance with certain general plans which you had suggested. We have examined the lands in question, have measured numerous springs and mountain streams, have examined various sites for storage reservoirs and surveyed several of them, and have made a somewhat detailed study of the practice of irrigation of sugar cane on this and adjoining islands of the group, and report our conclusions as follows:

THE NECESSITY FOR IRRIGATION.

Although sugar cane is successfully grown in some localities on the windward side of the islands of Hawaii and Maui without artificial irrigation, it appears to be confined to localities where the annual rainfall is somewhat evenly distributed throughout the year, and in volume equal to or exceeding the quantity which experience has shown to be necessary to apply to dry lands to mature the crop. These conditions do not exist on the island of Oahu, except on mountain slopes too steep for cultivation, or in some localities on the windward side, where some irrigation would nevertheless be advantageous.

It therefore goes without saying that irrigation is so essential to success in agriculture that no sugar cane can here be successfully grown without it, notwithstanding the fact that the minimum rainfall generally exceeds 24 inches along the coast (which in California is ample for nearly every crop grown there without irrigation) and from 40 to 90 inches on the mountain slopes.

THE DUTY OF WATER.

The necessity for irrigation being thus recognized and established, the quantity of water required in irrigating various crops becomes the next consideration, or, in other words, the duty that may be expected from a given volume of continuous flow. Our investigations on this subject have been as thorough and exhaustive as our time would permit. They have been conducted in detail not only on this island, but elsewhere in the group, although confined solely to the culture of sugar cane, which we have understood is the product to which it is desired to devote as large an area of the lands in question as may be possible.

Rice and sugar cane require more water than any other irrigated crop the world over, the former needing considerably more than the latter. In Spain and in India a cubic foot of water per second in continuous flow will irrigate from 25 to 35 acres of rice and from 45 to 65 acres of sugar cane. These are about the limits given by all authorities on the subject not only in the countries named, but in Algeria, Egypt, Italy, Japan, and other portions of the globe where these products are grown. We have found these figures to be substantially corroborated by the experience in these islands in the irrigation of sugar cane. It seems to be the general practice here to irrigate "plant" cane every 3 to 4 days for the first month after planting, or until it has made a strong growth of root and stalk. After that a watering is given once every 7 days for a time, diminishing to one watering every 10 days, which is continued for about 15 months from the time of planting, or until the maturity of the cane. It is customary to cease irrigation from 1 to 3 months before cutting. If, as in some districts, the cane did not mature short of 18 or 20 months from time of planting, the period of irrigation would be from 15 to 18 months. In making our estimates we have assumed that 15 months of irrigation would be the average required for sugar cane on the southerly slopes of this island (Oahu). Three waterings a month is the least that is considered safe to apply to keep the cane growing without check. In localities corresponding in position and climate with Honolulu it is customary to maintain this periodical irrigation regardless of the rainfall. The rain may at times exceed the quantity applied artificially but irrigation is performed as usual notwithstanding, in order that there shall be no break in the continuity of the waterings. It seems to be generally understood by all planters that the depth of each watering shall be at least an average of 3 to 4 inches over the whole surface. Where the intervals between waterings are 10 days and the depth applied 4 inches, 1 cubic foot of water per second will perform a duty of 59.5 acres. With intervals of 7 days and the same depth applied, 1 cubic foot per second would irrigate but 41.6 acres, or 55.5 acres if the depth applied is but 3 inches.

On the plantation of the Hawaiian Commercial Company at Spreckelsville, Maui, we were unable to obtain more exact data than elsewhere, owing to the admirable system of records kept by direction of Hugh Morrison, esq., general manager, who kindly furnished us with all information asked. The plantation is irrigated from the Haiku ditch, gathering its supply from some 20 small streams to the eastward of the plantation, and by the Waihee ditch, deriving its waters from the Waihee Creek, some miles to the west. Each ditch delivers to the plantation a maximum supply of about 65 cubic feet per second, but this maximum is not often reached, and the ditches appear to be subject to great fluctuation in supply. Several small storage reservoirs along the route serve to equalize the fluctuating discharge to some extent. Measuring weirs are placed on each in such position that the quantity of water actually delivered to the fields is recorded with great exactness by automatic registering apparatus. The volume of water put upon every field is thus known, and the date and quantity of each watering. The records further show in every detail all the results

obtained from each field, including the average yield of each in sugar per acre, as well as per unit of water applied. The record for the calendar year 1888 shows that there was delivered to the plantation the following quantity of water:

	Cubic feet.
From the Haiku ditch.....	1, 175, 000, 000
From the Waihee ditch.....	919, 000, 000
A total of.....	2, 094, 000, 000

or 15,700,000,000 gallons. (The rainfall during this period was 19.08 inches.)

With this water there were irrigated 2,000 acres of "plant cane" and 600 acres of "ratoons" (volunteer second crop). In addition, 400 acres of seed cane were irrigated once a month, consuming a quantity roughly estimated at 70,000,000 cubic feet. The remaining 2,024,000,000 would be equivalent to an average flow through the year of 64.18 cubic feet per second, which, divided into 2,600 acres, would appear to give an average duty of but 40.5 acres per cubic foot per second, and to indicate that the mean depth applied was nearly 18 feet in the aggregate. An explanation of this seemingly low duty may be found in the fact that the ditches supply water for all other uses on the plantation as well as irrigation. The amount consumed by the sugar mills, steam boilers, locomotives, and steam plows, as well as some 1,500 employés, some of whom have little gardens to be irrigated, if it could be known, would be very considerable in volume. In addition to this, the loss by evaporation and percolation in the ditches and reservoirs below the measuring weirs is doubtless considerable; all of which, if deducted from the total volume delivered, would probably raise the duty of the remainder to more than 50 acres per cubic foot per second.

Mr. Morrison states, as an epitome of his experience, that "11,000 cubic feet per acre applied every 7 days will produce the very best results in growing sugar cane." This measure would give a duty of 65 acres per cubic foot per second. Mr. Morrison further adds that it is almost impossible to put on too much water (of course within reasonable limits), and that the more water is applied, without going to extremes, the greater the yield. He has obtained a yield as high as 10 tons of sugar per acre in localities sheltered from the wind. The average yield of 1888 on 2,000 acres of plant cane was $5\frac{1}{2}$ tons of sugar per acre; the ratoon crop averaged $3\frac{1}{2}$ tons per acre.

With these figures one may form deductions as to the productive value of water. The total sugar crop was 13,500 tons. The total "water crop," if we may be allowed the expression, was an average flow of 64.18 cubic feet per second. The ratio of water to sugar was about 210 tons of sugar to each cubic foot per second of water, continuous flow. In other words, if we assume sugar to be worth \$40 per ton, after deducting cost of production, interest on plant, tools, and lands, the value of the water may be taken in the ratio of the results accomplished by it, viz, \$3,400 per annum for each cubic foot per second of continuous flow. This would represent interest at 10 per cent. on \$34,000. Water can be pumped 100 feet high for about one-fourth of the annual producing power quoted above.

On the Wailuku plantation, island of Maui, where the water supply is very abundant and in excess of the needs of the plantation, the consumption is equal to a duty of about 50 acres per cubic foot per second on plant cane and 60 acres on ratoons.

On the Hamaknapoko plantation, Maui, where the average annual rainfall is reported at 35.2 inches, the amount applied is stated by the superintendent, Mr. James Cewan, to be 10,890 cubic feet per acre to each watering; the intervals between waterings are 7 days, and consequently the duty of water in continuous flow is 55.5 acres per cubic foot per second. In making up these figures, however, Mr. Cowan qualified them by saying that they are for the full capacity of the ditch, which is not always full when required, and is only partially compensated for full flow by the rainfall. The probabilities are that if the exact flow of the ditch were known, its duty would average higher than $55\frac{1}{2}$ acres per second-foot. Mr. Cowan estimates that 566,280 cubic feet of water per acre are required for 12 months of irrigation, which is exactly 3 inches every 7 days, and states that fluctuations in rainfall do not materially affect irrigation or the amount applied. The average yield of the plantation is given at 5.6 tons of sugar per acre for plant cane and 4 tons for ratoon crops. In his courteous response to our letter of inquiry, he summarizes by stating that "to raise 1 pound of sugar requires about 51.8 cubic feet of water."

On the Waiāluā plantation, Oahu, the results obtained are greater than those observed elsewhere. We were shown a pipe line, 9 inches in diameter, 2 miles long, leading from the Haukonahua gulch (from which all the water for irrigation is derived), with a fall of 16 feet per mile, the flow from which irrigates 100 acres of sugar cane, as we were informed. The discharge of such a pipe would be 1.11 cubic feet per second, and the resultant duty 90 acres per cubic foot per second. Another 9-inch pipe

* It will be seen further on that our estimate is somewhat more liberal, and that we allow over 60 cubic feet of water to produce a pound of sugar.

line discharged 1.17 cubic feet per second, and also irrigated 100 acres. The duty of the water so delivered was an average of 85 acres per cubic foot per second. A ditch carrying $3\frac{1}{2}$ cubic feet per second was said to water about 200 acres; an average duty of 60 acres per cubic foot per second. The location of this plantation on the windward side of the island, where the rainfall is much greater than on the lee side, may account for the higher duty accomplished by the water in use, although no data was obtainable as to the extent or distribution of the rainfall on that side.

On the Kekaha plantation, Kauai, water is obtained by pumping to a height of 18 to 36 feet—an average of about 27 feet. The delivery of the water is contracted for at the rate of \$35 per acre per annum. The contractor is required to deliver sufficient water to irrigate 700 acres every 10 days, to an average depth of 4 inches at each watering. The duty thus performed, presuming the quantity contracted for is fully delivered, would be $59\frac{1}{2}$ acres per cubic foot per second. The pumping is done during 10 hours each day. The 3 pumps require to have a capacity of 7,000,000 gallons per day each. Coal costs \$14 per ton at the pumps. A very unusual yield is reported from this plantation. Ratoon crops for 7 consecutive years are said to have produced an average of 5 tons of sugar per acre each year. Our authority for these results is Mr. Glade, of the firm of Hackfeld & Co., Honolulu.

The conclusions that may be drawn from all the evidence we have obtained on the subject are:

(1) That while the duty of water is variable with all the varying conditions of soil, climate, rainfall, wind, exposed or sheltered locality, and in some degree with the length of time the land has been irrigated, such variation is generally between the limits of 40 acres as the minimum and 90 acres as the maximum duty of 1 cubic foot per second.

(2) That economy in the application of water below a certain limit, which, for the southerly slopes of this island seems to be about an average of 1 foot in depth per month, can only be exercised at the expense of the yield of sugar.

(3) That a greater duty than 60 acres per cubic foot per second can not be counted on with safety; or, in other words, that 325,500 gallons per acre are needed monthly, or to mature a crop say fifteen times that amount, or 4,927,500 gallons, are required. In estimating on the cost of pumping water for irrigation these are convenient figures to remember.

THE WATER SUPPLY.

Our attention was first directed to the water supply that might be made available for irrigating the Honouliuli rancho. This great body of land is bounded on the west for some 12 miles by the summit crest of the Waianae Mountains, a range isolated from the Koolau-poko Mountains, or the main central range of the island. From the foothill slopes of the Waianae range a broad plain sweeps south and east to the eastern boundary of the rancho to Pearl Harbor and the ocean. This plain at its northerly limit has an elevation of 1,200 feet; that portion above an elevation of 150 feet is some 9 miles long, 1 to 2 miles wide, and has an area of about 12,000 acres. Below an elevation of 20 feet is a broad extent of coral lands extending from Pearl Harbor along the ocean to Waimanalo, containing some 11,000 acres. The rancho, exclusive of Puuloa, has a frontage of nearly 5 miles on Pearl Harbor and 11 miles on the southerly seacoast of the island.

The area of the arable and irrigable lands (from surveys of C. H. Kluegel, c. e.) is about 17,000 acres (not including coral lands), divided as follows:

	Acres.
Below 50 feet elevation	1,637
Between 50 and 100 feet elevation	2,276
Between 100 and 150 feet elevation	1,177
At Waimanalo (estimated)	600
Plains above 150 feet elevation (as shown on map)	12,000
Total	17,690

The large body of arable land below 150 feet elevation extends from the right bank of Waialeale gulch in a southwesterly direction about 5 miles, and is from 1 to 3 miles wide. The surface of this land, as well as that of the upper plain to the north, is generally smooth, only broken by occasional dry gulches from the mountains, which in winter bring down torrents of water heavily laden with silt and vegetable mold, which is deposited upon the lower levels of the plain.

The soil seems of exceptional quality, and by comparison with other plantations appears to be well adapted to the culture of cane. It has been so pronounced by experts more capable of judging than ourselves.

It is probably a conservative estimate to place the area of sugar land at 14,000 acres, 5,000 below 150 feet elevation, and 9,000 from 150 to 900 feet above sea level. This area would require for its irrigation a quantity of water equal to 233 cubic feet

per second. To what extent this water may be obtainable and from what sources will now be considered.

There are no living streams flowing through or across the tract from the Waianae Mountains, and although we made no special examinations to determine the possibilities in the way of storage of storm waters, their steep slopes seem rather unfavorable for the existence of any extensive natural sites for storage reservoirs, although something may doubtless be done by the tank system on the plains themselves. A careful topographical survey of the property would give this information. The other sources of supply available are:

1. Storage reservoirs on the Waikakalaua and Kaula gulches, both of which have large watersheds and living streams, and have favorable sites and good material suitable for storage reservoir dams. The same may be said in a lesser degree of Kipapa gulch, while the Waiawa gulch farther to the eastward affords a superior reservoir site near its mouth. Water from the first three could be conveyed to the higher levels of the plains; the last could only contribute to the lands lying below 20-foot elevation.

2. Natural springs of large volume that burst out around the margin of Pearl Harbor.

3. Artesian wells.

The first-named supply could be conducted to the lands by gravity. The second and third would involve the lifting of the water to the required height by pumping.

SUPPLY FROM SPRINGS.

Our attention was first called to the springs that burst out from the foot of the low bluffs along the margin of the semiswamp lands of Pearl Harbor, and we can not here refrain from expressing our surprise and astonishment at their phenomenal volume and extent. They furnish a supply for irrigating some 2,000 acres of rice fields and a large area cultivated to bananas and taro, and in addition such large quantities go to waste, or at most are only used to furnish water-power to various rice mills, that strong streams navigable for small boats pour continually into the bay.

It is owing to this great supply of fresh water that Pearl Harbor doubtless owes its existence and the coral insect has been kept from closing its entrance.

The largest and strongest streams come from the bluff at a height of 20 to 25 feet above the tide level, and from this height all the way down to sea level the slopes for miles are like a great sponge full of water, oozing out in a myriad of little streams. Even in the bay beyond the shore springs break out so strongly that it is said cattle and horses have been seen to wade out to them, plunge their nose under the salt water and drink from the fresh fountains bubbling up from beneath.

Our measurements were confined to the streams which now flow to waste unused for irrigation. The first was at Kalanso, near the mouth of Waimalna gulch, at Ah In's rice mill, where a portion of the stream is used to turn an overshot wheel. The total flow in the boat channel below the mill was found to be 27.8 cubic feet per second. The aggregate of the flow at Aki's rice mill was found to be 10½ cubic feet per second.

The Puikani springs, about one-fourth mile west of Aki's rice mill, have a flow of 13.4 cubic feet per second.

In the vicinity of the present terminal station of the Oahu Railroad are springs having an aggregate flow of 9½ cubic feet per second.

The unused water from springs near the mouth of Waiawa gulch is about 5 cubic feet per second in volume.

Large springs lying near and southwest of Waiawa church are held up to the highest level of their flow to obtain power to turn a rice mill. The free discharge from this aggregates about 8 cubic feet per second.

The largest group of springs was found at and above the mouth of Waikelo gulch, the total unused flow from which was found to be 42.5 cubic feet per second.

We recapitulate the measured flow of unused water as follows:

Localities.	Flow per second.
	<i>Cubic feet.</i>
Ah In's rice-mill springs.....	27.80
Aki's rice mill springs.....	10.33
Puikani springs.....	13.40
Mausoleum springs.....	8.25
Waiawa gulch springs.....	5.00
Waiawa rice-mill springs.....	7.83
Waikelo Creek springs.....	42.50
Total.....	116.11

These springs all lie within a range of 3 miles, and, as before explained, the volume here given represents only the larger streams that were gathered in such channels as admitted of measurement, and such as were not already appropriated and used for irrigation of the extensive rice fields that fringe the bay below them. It represents, too, the natural flow forced out against all impediments, and that after 18 months of exceptional drought.

We do not hesitate to say that a systematic development of these springs would result in a large increase of the flow. Small drains in all directions through the extended areas of oozing ground, now so wet as to make unsafe footing, would so facilitate the drainage as to cut off the water that finds its way to the sea without entering the channels where the flow was measured. In southern California, where similar springs or "cienegas" are of frequent occurrence, development by drain ditches, tiles, and borings has not uncommonly resulted in double, and sometimes quadruple, the natural flow. A definite plan for such work can only be laid out after special survey and study of each locality are made. The present measured flow, as given on the preceding page, is sufficient to irrigate 7,000 acres of sugar cane; and we have no doubt that the supply can be increased sufficiently to provide for 10,000 to 12,000 acres if necessary. It would not be a difficult matter to collect all the water into one central pumping station if it was considered desirable to do so. It would probably be preferable, however, to establish two or more pumping plants, and deliver the water from each to the plantation nearest to the supply.

THE ARTESIAN-WELL SUPPLY.

The discovery of the possibility of obtaining a supply of flowing water by deep artesian borings around the margin of this island has been of incalculable value to all property interests, and has compensated in a measure for the loss occasioned by the perpetual robbery of the waters that fall so copiously upon the mountains, by the porous and thirsty earth, and for the waters lost during torrential storms by rapid drainage into the sea. On no other island of the group has nature provided for such compensation, and even here the geological formation is so different from that of any other region the world over where artesian water is obtained by boring, that no scientific man would have risked his reputation in predicting the possibility of securing flowing wells by boring in the volcanic and coral formations of this country before success had demonstrated the fact.

Mr. James Campbell, the present owner of Honouliuli and Kahuku, is credited with the distinction of having been bold enough to try the experiment which resulted in the first flowing well in the kingdom. This well was bored 10 years ago on the lower slopes of Honouliuli rancho, and a good flow obtained at a depth of 273 feet. It has been followed by so many successful attempts in the same direction that the flowing wells on the island now number over 100, some of which equal, if they do not exceed, the flow of the largest and most famous wells in California. One of a group of four wells bored by Judge McCully on King and Beretania streets, Honouliuli, was carefully measured a few days since by Messrs. Allardt and Kluegel, and the flow was ascertained to be 3.98 cubic feet per second, or 2,580,000 gallons in twenty-four hours. The combined flow of the four wells was ascertained to be 10.68 cubic feet per second, which is equivalent to about half the present water supply of San Francisco, a city of more than 300,000 inhabitants. Two of the smallest of them, flowing 4.1 cubic feet per second, are now made to irrigate 100 acres of rice.

A marked peculiarity of this artesian belt is that it is confined to a marginal rim around the island from sea level back to an elevation of 21 to 42 feet above. In and around the city of Honolulu, or the Kona district, water will flow at the maximum height of 42 feet. In this district also the largest and strongest wells are obtained. In the Ewa district, which includes all the margins of Pearl Harbor and Honouliuli, the limit of rise is 32 feet; in the Waialua district it is 21 feet, and in the Koolau district on the north side of the island, embracing the Kahuku rancho, the limit is 26 feet. This data is obtained from the last edition of Thrum's Almanac, in which is given a list of all the wells and their depths. From this list it appears that the deepest flowing well is that of Hon. C. R. Bishop in this city, 1,000 feet in depth. The one of least depth is at Waialua, on Dickson & Paty's ranch, 200 feet in depth. Five hundred feet is thought to be about the average depth. A record of one of Judge McCully's wells shows the following strata passed through:

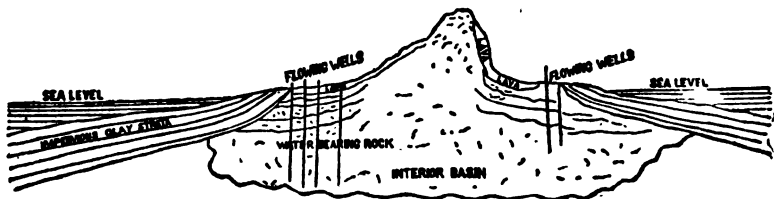
Surface soil, coral, gravel (with water that rose a little way in the pipe), volcanic ashes and pumice, rock, water-worn bowlders, ashes, volcanic rock, clay, water-bearing gravel.

Experience thus far indicates that flowing water is almost certain to be obtained anywhere around the margin of the island where the surface is lower than the limits above mentioned. The foot of Diamond Head seems to be an exception to this rule, Mr. Campbell's well, recently bored in that locality, 1,500 feet in depth, having failed to yield a flow.

Up to date it may be said that the artesian supply is practically unlimited, as the addition of new wells does not diminish the flow of others in their vicinity. There seems to be a more or less direct connection between the wells and the streams from the mountains, and we have been told of at least one well that flows muddy water some hours after a heavy storm.

The springs that appear at and above sea-level all around the island, and the artesian wells, undoubtedly have one and the same source of supply and are fed from the same interior basin that overflows at or near sea-level. This supply is maintained by direct absorption of the rainfall by the porous lava rock and by infiltration from the mountain streams. The fact that water will rise in the well-pipes a few feet higher than the level at which the springs appear indicates that the open well-pipe affords a freer outlet than is afforded by the seams and crevices through which the water of the springs is forced, permitting the water to rise to nearly its full static head. The probabilities are that the island is surrounded by deep, thick strata of impervious clay or sedimentary formation, built up by slow deposit from the wash of ages by the streams of the islands; that these strata lap onto the land to or about the height the water rises in the wells, brought up by the gradual rise of the island above sea-level, and that these strata prevent the escape of the waters into the sea beneath them.

The following diagram, showing an imaginary cross section of the island, will serve to illustrate the theory:



However, it is not our purpose to burden this report with scientific theories of little practical value. If it is true that the wells and the springs are supplied from the same source, we do not think this source is sufficiently limited to cause any apprehension that the extended boring of artesian wells on Honouliuli plains would diminish the flow of the springs.

It would be equally fruitless to attempt to estimate the amount of water obtainable by boring wells. So far as anyone knows, it is practically inexhaustible. If you obtain control of the unused springs around Pearl Harbor, they alone are more than sufficient to irrigate all lands below a height to which it will pay to pump water, and the probabilities are that wells would only be bored in case you failed to obtain sufficient water from other sources, or in localities so remote from the springs that it would be cheaper to bore for water than to carry it long distances through pipes or ditches. Both springs and wells seem to be at your command, and, so far as we are able to judge, either may be made to suffice for your purposes.

PUMPING WORKS AND COST OF PUMPING.

To utilize either the springs or artesian wells for irrigation will involve the erection of pumping works.

As heretofore stated, exclusive of the 600 acres estimated as available for growing sugar cane at the Waimanalo end of the coral lands, there are 5,500 acres of good tillable land below the elevation of 150 feet, of which 79 per cent. or 4,300 acres are below 100 feet altitude.

The 600 acres at Waimanalo should be supplied by artesian wells, on account of their remoteness from the other sources of supply. The greater portion of the tract is said to be below 50 feet altitude, consequently the cost of pumping would be comparatively moderate.

The remaining 5,500 acres will require about 92 cubic feet of water per second to irrigate it fully. Nearly one half this quantity, as we have already stated, is running to waste in Waialeale Creek, and if the right to use it is secured, a plantation of 2,700 to 3,000 acres could be immediately started.

If we knew definitely whether the irrigable lands were to be divided into one or half a dozen plantations we could formulate more definite plans for the pumping plant, water conduits, etc. In default of this information we can only make estimates from hypothetical cases.

Assuming that the springs were under one control, and that the water were to be

supplied to the lands under one management, the design of the works would be simpler than if the lands were cut up into several plantations, each pumping water by separate systems.

It is perhaps unnecessary to remark that water may be pumped in large quantities at less average cost per 1,000 gallons than in small quantities, and that the most economical engines are those which extract the greatest amount of power from a given quantity of coal, or that do the most work per unit of coal. Engines of the compound condensing type are used for this class of work, because of their high duty. They require to be run continually, however, night and day. For this reason provision must be made for storing the water pumped at night for the following day, as it is not considered practical or desirable to irrigate sugar cane at night on account of the difficulty of doing the work properly without injury to the cane. The best engines should give a duty of 100,000,000 foot-pounds per 100 pounds of coal. Direct acting engines do not often exceed 60,000,000 foot-pounds per 100 pounds of coal, while centrifugal pumps, forcing water about 20 to 25 feet, do not give a greater duty than 20,000,000 to 25,000,000 foot pounds. The expense of operation for a permanent plant becomes a serious, and indeed the main consideration, where such a wide duty is obtainable from different classes of pumps.

We submit the following as a reasonable estimate of the cost of a pumping plant capable of delivering 30,000,000 gallons per day to a height of 100 feet, a quantity sufficient to amply irrigate 2,800 acres of sugar cane:

Five compound condensing engines, each having a capacity of 6,000,000 gallons daily, steam cylinders 20 and 36 by 48, running 33 revolutions per minute, water cylinders 14½ by 48 stroke, at \$32,500.....	\$162,500
Seven 180 horse-power Heine-Safety boilers, at \$4,000.....	28,000
Foundations for engines, 35,000 cubic feet concrete, at 60c.....	21,000
Brick work.....	6,500
Erecting engines and boilers.....	16,000
Excavations, pump-well, etc., say.....	10,000
Piping and feed pumps.....	12,000
Engine house.....	25,000
Freight to Honolulu.....	5,000
Total.....	286,000

To this must be added the pipe needed for delivery to the lands at the height required. The diameter of this pipe should be 36 inches. The maximum velocity of water through a pipe of this size will be 6.6 feet per second. If the plant were located on Waialeale Creek, near the public road or but a little way below, the length of pipe necessary would be very short to reach the lands, say about 3,000 feet, and its total cost laid would be about \$14,000, which brings our total estimate of cost up to \$300,000.

The engines here estimated on are the best type of Reynolds-Corliss horizontal pumping engines, as manufactured by the Risdon Iron Works of San Francisco, by whose agent in this city, Mr. Jno. Dyer, the above figures have been verified.

The cost of pumping per day will be about as follows:

One chief engineer, at \$175 per month.....	\$5.75
Two assistant engineers, at \$100 per month each.....	6.65
Three coal passers, at \$40 per month each.....	4.00
Five oilers, at \$40 per month each.....	6.65
Fifteen firemen in three shifts, at \$40 per month each.....	20.00
Oil and waste, say.....	39.45
Coal, on basis of 2½ pounds consumption per horse-power per hour, 700 horse-power by 2½ = 1,758 pounds per hour = 18½ tons per twenty-four hours, at \$10.....	187.50

Total..... 270.00

This gives an average cost of nine-tenths of 1 cent per 1,000 gallons. The estimate is sufficiently liberal, and with good Sydney splint coal should not be exceeded. Applied to the quantity required for irrigation, the cost foots up *about \$3 per acre per month, or \$1 for each watering per acre, or about \$36 per acre per annum, or \$45 per acre per crop.* For a lift of 200 feet, the cost of engines would be about 50 per cent. greater than for a lift of 100 feet, and the expense of operation would be about double the above figures, or say \$90 per crop or \$72 per annum.

In California, this expense for water would be considered prohibitory and unjustifiable by the returns from any crop that can there be produced, but here a greater cash yield may be had from a crop of sugar grown from low land in 18 months than is obtained from the best of their orange groves after 12 to 15 years of cultivation, and what would otherwise appear as an excessive tax comes within reasonable bounds.

We have the permission of Mr. Hugh Morrison, general manager of the Spreckels-

ville plantation, to quote him as giving his deliberate opinion that on good sugar land, by which is meant land that will yield good average crops of sugar, one can afford to pay as much as \$100 per acre per annum for water sufficient to irrigate it abundantly.

With sugar at 6 cents per pound and an average yield of but 4 tons per acre per crop, the gross yield would be \$480 per acre, and the net results about as follows:

Cost of irrigating, stripping, weeding, cutting, transporting, grinding, and manufacturing, say \$50 per ton. (Mr. Morrison states that the average cost of his entire crop of 1883, landed in San Francisco, was but \$44 per ton.) Four tons, at \$50.....	\$200.00
Water, lifted 100 feet high.....	45.00
Interest on pumping plant for 2,800 acres, costing \$300,000, at 10 per cent. for fifteen months = \$37,500 = \$13.40.....	13.40
Total.....	258.40

This leaves a net return per acre of \$221.60, or, on a plantation of 2,800 acres, a net yield of over \$600,000 per annum. Even with sugar at 4 cents per pound, the net returns on a yield of 4 tons per acre would be over \$60 per acre per annum, or \$15 per ton.

It would be advisable to develop all the land that is irrigable below an elevation of 100 feet before planning pumping works for a higher lift. As we have seen, the area below that level is sufficient for the establishment of a greater plantation than is now in existence on any of the islands, with water in abundance for it.

STORAGE RESERVOIRS.

There is abundant evidence to show that during heavy storms all of the main streams from the mountains carry large volumes of water to the sea, notwithstanding the fact that a very large percentage of the rainfall is absorbed by infiltration into the porous earth. This infiltration would be much greater than it is if all the rainfall came in gentle showers, evenly distributed through the year; but whenever storms occur in which the precipitation exceeds 1 or 2 inches in 24 hours, absorption can not take up the water as fast as it comes, and the excess finds its way rapidly into the streams and flows away. Every stream shows high-water marks that indicate the frequency of such storms, which are said to occur with more regularity in the winter months, but may be expected throughout the year at any time. These high-water marks also indicate that very small watersheds may yield a large quantity of water, and though there is no guide as to the duration of the freshets or the intervals between them, they show that the rainfall on the mountains must at times be very great. The only rainfall records available as an indication of what the mountain precipitation may be are those kept for 19 years, from 1867 to 1884, by J. H. Woods, in Nuuanu Valley, 2½ miles back from the seashore, and at an elevation of 554 feet above tide, and by Mr. J. K. Wilder, in the immediate neighborhood of the former, for 6 years, from 1879 to 1884. Mr. Wood's record is as follows:

Year.	Rainfall.	Year.	Rainfall.
	<i>Inches.</i>		<i>Inches.</i>
1867.....	75.21	1876.....	88.57
1868.....	77.10	1877.....	54.12
1869.....	53.67	1878.....	49.12
1870.....	80.29	1879.....	95.94
1871.....	67.14	1880.....	95.28
1872.....	65.46	1881.....	78.86
1873.....	67.03	1882.....	54.69
1874.....	80.16	1883.....	50.62
1875.....	55.69		

The mean rainfall for this period was 62.6 inches. For 6 years, from 1879 to 1884, the mean rainfall was 69.48 inches, distributed as follows:

Year.	Rainfall.	Year.	Rainfall.
	<i>Inches.</i>		<i>Inches.</i>
January.....	9.69	July.....	5.55
February.....	3.82	August.....	6.38
March.....	8.12	September.....	3.88
April.....	6.20	October.....	4.62
May.....	3.28	November.....	5.06
June.....	6.52	December.....	6.78

The greatest rainfall in the different months during this period was as follows:

Year.	Rainfall.	Year.	Rainfall.
	<i>Inches.</i>		<i>Inches.</i>
January	27.14	July	7.12
February	6.44	August	7.64
March	14.01	September	5.40
April	7.69	October	10.12
May	8.44	November	7.53
June	9.73	December	2.02

The records of Mr. Wilder practically agree with those of Mr. Wood.

The well-known fact that the rainfall increases in more or less direct ratio with the elevation, and the further fact that the records here quoted show an increase of 100 to 150 per cent. greater than that at or near sea-level in Honolulu, would justify the belief that at elevations from 1,500 to 2,000 feet the mean precipitation is at least double that recorded at 554 feet elevation, and probably much more. Our own observations since coming to the islands is that rain is falling on the mountains more than half the time, when there is no rain on the coast. In the absence of more exact data we have assumed as a conservative estimate that not less than an average of 80 inches of rainfalls annually on the watersheds of the southerly side of the Koolau-poko Mountains, of which 45 per cent., or 36 inches, runs off to the sea, available, for any storage reservoirs that may be built.

Waiawa Gulch Reservoir.—The first reservoir site surveyed was on Waiawa Gulch, one-fourth mile above the Ewa road-crossing, where a dam, having an extreme height of 93 feet and a length on top of 207 feet, will store 3,631,312,500 gallons of water, making a reservoir covering 276 acres, with an extreme length of $2\frac{1}{2}$ miles.

The best material available is an excellent quality of red earth or clay, which is sufficiently abundant in the immediate vicinity. An earthen dam, with a width of 20 feet on top, upper slope $2\frac{1}{2}$ to 1, lower slope 2 to 1, would contain 258,700 cubic yards, and should be built with all accessories for \$175,000 to \$200,000.

Its area and capacity at different levels are given in the following table:

Elevation above sea level.	Area.	Total contents.
<i>Feet.</i>	<i>Acres.</i>	<i>Gallons.</i>
30	23	
40	78	163, 500, 000
50	119	485, 062, 500
60	147	919, 312, 500
70	170	1, 437, 843, 750
80	198	2, 039, 843, 750
90	250	2, 771, 718, 750
100	276	3, 361, 312, 500

Sixty per cent. of the capacity, or 2,194,000,000 gallons, is contained at an elevation above 70 feet, and if that portion only of the reservoir were utilized and the water conveyed to Honolulu, it would command all the irrigable land below 50 feet elevation, which is about 2,200 acres, including Waimanalo.

The watershed area is 16,500 acres. With an average of 3 feet of rainfall drained off this area it would furnish water enough to fill the upper 30 feet of the reservoir $7\frac{1}{2}$ times during the year. If it were filled but once a year it would irrigate 550 acres. If it were filled four times a year it would water 2,200 acres. This is about what we think is reasonable to expect it might do; and if that assumption be correct, it would afford cheaper water than could be obtained by pumping.

If the dam and conduit to the lands cost \$242,000 it would represent an expense of \$110 per acre on 2,200 acres. This would be a reasonable estimate for the cost, unless unforeseen difficulties should be encountered in the foundations. Our estimate shows the cost of a pumping plant for 2,800 acres to be \$300,000, or \$107 per acre. The delivery of water from the dam after it was once properly constructed would be comparatively inexpensive—very slight as compared with the constant expense of pumping.

All things considered, the gravity works would be decidedly preferable. All depends of course on the annual flow of the stream and its distribution in such manner as to fill the reservoir every 3 months. Any failure or irregularity in that flow would tend to diminish the duty of the reservoir and increase the average cost to the lands

actually served by it. The importance of the subject is sufficient to warrant the construction of a weir in the stream, where a record of its flow might be kept for a period of some months—long enough to give some assurance of what may be expected from it.

The Waikakalana Reservoir.—A survey was made by Messrs. Allardt and Kluegel of a reservoir site on Waikakalana Gulch, the dam site being located about 1,000 feet below the bridge on the Waialua road, at an elevation of 580 feet above sea level at base, and the reservoir extending above the bridge about three-fourths mile. The top of the dam, as surveyed, will be 665 feet above tide, and the waters stored may be conveyed to the Honouliuli plains with about 3 miles of conduit, reaching lands below 500 to 550 feet elevation. The contents of the reservoir would be about as follows:

Elevation above sea level.	Area.	Total con- tents.
<i>Feet.</i>	<i>Square Feet.</i>	<i>Gallons.</i>
580	58,000	-----
600	550,000	22,725,000
620	1,475,000	98,662,500
640	2,775,000	253,037,500
660	4,325,000	524,287,500

This volume, if the reservoir be filled once a year only, would maintain a constant flow of $2\frac{1}{2}$ cubic feet per second, without allowance for loss by evaporation, which need not be regarded, as the living stream would probably be sufficient to supply it.

The area of the watershed is about 4,500 acres, all above 600 feet elevation, and having an average rainfall annually probably exceeding 90 inches. Three feet in depth drained off the watershed would suffice to fill the reservoir 9 times a year. As this amount is not an unreasonable quantity to expect, unless we are much deceived as to the rainfall and the periodical freshets, it is quite likely that the reservoir would be filled once every 6 weeks, as its filling would require but 4 inches drained from the entire watershed, which we judge is not ordinarily beyond reasonable expectations.

On this basis, therefore, the reservoir may be considered equivalent to a reservoir of nine times its capacity filled once a year. This would afford a constant stream of 20 cubic feet per second, a supply adequate for 1,200 acres of sugar cane.

The dam would be formed of earth, of which a superior quality well suited for the purpose is at hand. A dam 20 feet wide on top, with side slopes of $2\frac{1}{2}$ to 1 on the upper side, and 2 to 1 on the lower, would contain 157,500 cubic yards. Its cost should not exceed \$125,000 to \$130,000. Its length on top would be but 460 feet. The site for a dam is a favorable one, and the material is as good as could be desired.

The ordinary flow of the stream as we found it is about $1\frac{1}{2}$ cubic feet per second, which is considerably less than the flow 3 miles above. This is in a season of drought, and is represented to be far below the normal flow.

If our estimate of the regularity and frequency of the filling of the reservoir is correct, it would appear to be a very desirable location for a work of this kind. But so much depends upon meteorological data, which is not obtainable except by continuous and somewhat protracted observation, that we can only submit our figures with the proviso—if.

In this case, as in that of the Waiawa reservoir, we recommend further observation and measurement of the stream before definite plans are decided upon.

THE KAHUKU RANCHO.

This well-known rancho occupies the extreme northerly point of the island, extending from the crest of the mountains to the sea, and from Waimea River on the west to Laie on the east. It is 33 miles distant from Honolulu, either by the Waialua or the Pali road. Its position on the windward side, with high mountains rearing up rapidly from the level of the belt of valley land along the coast, gives it abundant moisture and clothes it in perpetual verdure. Cattle roaming over its hills and valleys are all fat and sleek, and water is bursting out in places all along the coast, generally nearer the foot of the hills, or about midway between the foothills and the ocean. Near the ranch-house is a tract of 150 acres so full of springs that it has been fenced in to keep cattle from the danger of being mired and lost. One of the largest of these springs is about 100 feet in diameter and 40 feet deep. The general level of the land is about 20 feet above tide.

West of Promontory Point (a bold cliff putting out into the valley about midway of the rancho) this character of springs is met with at intervals nearly all the way to

the Waimea River. East of the point there are fewer springs on the surface, but the artesian well bored by Mr. Campbell, in the center of a large field of rank Bermuda grass, indicates that water exists abundantly below and only needs to be tapped to yield all that may be required. This well has a very strong flow, which we estimated roughly at 800,000 to 1,000,000 gallons daily, although we had no means of measuring it accurately. At the Mormon settlement of Laie, adjoining Kahuku on the east, are a number of flowing wells yielding a considerable volume of water.

The area of valley land available for sugar or rice culture is between 4,000 and 5,000 acres, all lying below 50 feet elevation and mostly lower than 25 feet. The flatness of the land renders it specially adaptable to rice, and more easily irrigated for sugar cane than land of steeper slope, while its low elevation would cheapen the cost of pumping.

There can be no question, we think, of the abundance of water supply available by development of the springs and by boring artesian wells for any plantation that might be started upon the lands, and this, we think, would equally impress the most casual observer.

The rainfall being so much greater than at Honouliuli the water needed for irrigation would be very appreciably less, and on account of the low lift the cost would be much diminished. We should not expect the cost of water for sugar cane to exceed \$10 per acre per annum.

The pumps used here would probably be of the centrifugal pattern on account of their simplicity and cheapness, and because the low lift would admit of their use with reasonable economy.

The soil of the Kahuku seems of the best quality wherever the coral does not outcrop, and taken all in all the transformation of Kahuku into an extensive sugar plantation would appear to be an extremely simple proposition, with all doubtful questions eliminated and expense of irrigation reduced to the minimum. The use of the low lands for this purpose need interfere but slightly with the utility of the rancho as a stock range, as good feed abounds in the hills and higher valleys as well as along the coast.

Although not pertinent to the lands treated of in this report, we may mention incidentally that en route to and from Kahuku we made measurements of water as follows:

	Per second.
Waimea River.....cubic feet..	8
Springs east of Kawaihoa River	25
Kawaihoa River.....do.....	60

Each of the two branches of the Waialua River apparently carries a larger stream at the road crossing than the Kawaihoa, but they were not measured. Their flow is augmented by springs above the road, 10 or 15 feet above the sea level. We conclude that in the vicinity of Kawaihoa ranch near sea level more than 100 cubic feet per second of unused water may be made available for irrigation and profitably pumped to the high lands in the immediate neighborhood for use in sugar culture.

In making these examinations we have been impressed with the fact that there is great need for a systematic study of the water supply available for irrigation throughout the islands generally by experienced hydraulic engineers—and the collection and publication of just such data as we have been groping for very much in the dark. This is a work which should properly devolve upon the Government, and is undertaken and regularly and continuously carried out in almost every other civilized country where irrigation is practiced. Where water is so valuable as it is here, it would seem to be quite worth while to take an account of stock occasionally, to ascertain what you have, what is done with it and what further good it can be made to accomplish.

In closing this report, already too long, we wish to assure you that we can fully substantiate every statement you have made to us prior to our investigation regarding the lands and the available water supply. And we can cheerfully add that in our opinion it is feasible and in your power to irrigate a very large area of the dry Honouliuli plains, and at reasonable cost, from the sources of supply within your reach, and that all of the coast valley land of Kahuku, exceeding 4,000 acres, may be readily and cheaply irrigated from the water supply directly at hand.

The advantage apparent in the location of both Honouliuli and Kahuku for sugar plantations over all others on the island is in the fact that the Oahu railway, already graded almost to the limits of Honolulu, and projected to reach Kahuku, will allow shipments to be made directly from the plantations to the principal port of the islands, enabling the sugar to be placed on shipboard at Honolulu from the cars without expensive transshipment, rehandling, and lightering, and giving equal facility

and cheapness to the transportation of heavy machinery, coal, lumber, and supplies to the plantations. This is an item of saving, the importance of which can not fail to be appreciated.

The accompanying map of Honolulu and vicinity has been compiled from the best data available.

Our grateful acknowledgments are due to the following gentlemen for information rendered, for delicate attentions shown and for many courtesies extended: Prof. W. D. Alexander, surveyor-general, Messrs. Castle & Cook, W. R. Castle, Mark Robinson, S. E. Bishop, C. A. Brown, Mr. Glade of Hackfeld & Co., and John Dyer of Honolulu, Messrs. Halstead & Sons of Waialua, and Messrs. Hugh Morrison, R. D. Walbridge, Maj. Wm. Cornwell, and James Cowan, of Maui.

All of which is respectfully submitted.

JAS. D. SCHUYLER, C. E.
G. F. ALLARDT, C. E.

CONTINENT OF EUROPE.

AUSTRIA-HUNGARY.

REPORT BY CONSUL-GENERAL GOLDSCHMIDT.

INTRODUCTORY REMARKS.

Although industrial enterprise has considerably increased within the last 30 or 40 years in Austria, agriculture still forms by far the principal occupation of its inhabitants, no less than 13,025,099 of people of a total population of 22,144,244 being engaged in the different pursuits connected with agriculture and forestry according to the last census, of 1880.

The soil is as a rule fertile, although the different districts widely vary in productiveness, according to their geographical position, their elevation, their temperature, rainfalls, etc.

In Austria about 94.29 hectares of every 100 are productive soil. There is, however, a considerable difference in the distribution of unproductive soil between the western districts and those of the east.

By diligence and exertion the entire cultivable soil of the western country is effectually cultivated, and the still-existing uncultivated areas may therefore be considered as actually uncultivable; in the east however there are large areas which still count among the uncultivable, but which with sufficient and cheap labor and by rational treatment might be transformed into cultivated lands.

Crops.—The crops grown in Austria amount in the average to the following quantities:

Wheat.....	hectolitres..	14,500
Rye.....	do...	26,100
Barley.....	do...	16,500
Oats.....	do...	33,400
Indian corn.....	do...	5,800
Buckwheat and millet.....	do...	3,700
		100,000
Leguminous plants.....	hectolitres..	2,500
Potatoes.....	do...	88,300
Flax.....	kilogrammes..	42,500,000
Hemp.....	do...	24,900,000
Sugar beets.....	do...	4,200,000,000
Tobacco.....	do...	4,000,000
Hops.....	do...	6,700,000
Olive oil.....	do...	14,000,000
Wine.....	hectolitres..	3,300

Bohemia, Galicia, Moravia, and Upper Austria also have a considerable rape-seed culture, crops amounting to about 600,000 hectolitres per annum.

The annual production of fruit amounts to about 700 millions kilogrammes, a great deal of which is exported.

Austria has very extensive woodlands, which cover more than one-third of the entire productive area.

The crown and the state own areas of woodland, principally in the Bukowina, in Galicia, Salzburg, and Tyrol, amounting to 898,000 hectares.

The average product of timber per annum amounts to 27,000,000 cubic metres, a considerable part of which is exported in the form of masts, staves, and lumber.

Hungary up to quite recent times has been almost exclusively an agricultural country. Its crops are about of the same kind as those in Austria, with the addition of melons, poppies, chesnuts, and mulberries for silkworm culture. Wine is one of the chief staples of Hungary, the annual production of which amounts to 9,000,000 and in good years up to 16,000,000 hectolitres.

Cultivation.—A general representation of the state of culture in the different provinces of Austria and in Hungary is given in the following table:

Province.	Percentage of productive area.						Total productive area in Austrian acres (joch).	Total percentage productive area.	Total percentage unproductive area.
	Grain, etc.	Rice-fields.	Vine-yards.	Meadows and gardens.	Pasture lands.	Olive, laurel, and chesnut groves.			
Lower Austria	41.96	.....	2.24	13.84	7.88	.....	3,233,986	93.68	6.12
Upper Austria	38.13	.....	.....	20.39	5.43	.....	36.05	1,893,702	90.84
Salzburg	11.88	.....	.....	13.25	38.12	.....	36.75	997,446	80.10
Styria	19.89	.....	1.83	12.77	16.75	.....	49.06	3,575,588	91.64
Carinthia	.....15	.....	.....01	12.48	26.38	.....	46.13	1,581,029	87.71
Carniola	14.42	.....	1.02	17.40	21.69	.....	45.47	1,642,323	94.67
Trieste, Goriz, Gradisca, and Istria	18.58	.....08	2.48	13.42	41.04	.....3	24.37	1,302,050	93.79
Tyrol and Vorarlberg	7.27	.....44	.....	15.06	30.99	.....3	46.21	4,079,160	80.04
Bohemia	49.59	.....02	.....	42.47	7.95	.....	29.97	8,750,063	96.92
Moravia	52.50	.....	1.07	8.90	10.32	.....	27.21	3,704,503	95.98
Silesia	48.62	.....	.....	7.67	10.91	.....	32.80	865,980	96.81
Galicia	48.00	.....	.....	13.64	10.46	.....	27.09	13,101,255	92.23
Bukowina	28.14	.....	.....	13.19	12.71	.....	45.96	1,761,856	89.44
Dalmatia	11.26	.....	5.58	.....97	59.00	.....125	21.94	2,164,938	96.31
Hungary	40.43	.....	1.61	13.87	17.19	.....	26.90	31,297,991	83.96
Croatia and Slavonia	30.68	.....	1.97	12.92	11.23	.....	43.20	2,901,403	86.63
Transylvania	26.16	.....	.....57	19.07	11.06	.....	43.14	8,281,255	86.52
Military Boundary District	29.53	.....	1.07	17.96	16.69	.....	34.75	4,672,729	80.15

As a summary, the foregoing table contains in its last three columns the actual measurement of productive soil in Austrian acres (joch)—1 joch being equivalent to 0.57646 hectares—and the percental proportions of the productive and unproductive areas.

As will be seen from the foregoing table, Bohemia, amongst all Austrian provinces, has by far the most meadows and gardens, viz, 42.47 per cent., whereas, Dalmatia shows the least, with only 0.97 per cent. on account of the poor Karst soil (Karst Mountains). Of grass land in general, that is, pastures, meadows, and gardens together, Dalmatia, however, shows the largest proportion, viz, 59.97 per cent.

In order to prevent any misunderstanding of this statement, it must be borne in mind that this entire percentage in Dalmatia represents

meager pasture land only. If the meadow land alone, without the meadows, only intermittently used as such, be included in the area of soil employed in agriculture, and not counting the permanent pastures, it becomes evident that the former, the meadow land, amounts in the maximum, in the mountainous part of the Voralberg district, to 92.8 per cent. of the entire area of agriculture, while its minimum, viz, 0.2 per cent., exists in the most southern coast district of Dalmatia.

The hay crop of the (perennial) meadows is largest in the upper Etsch-Valley district of Tyrol, in central and lower Styria, and south of the Danube in upper Austria, as well as in the neighboring part of lower Austria, and amounts to 3,200 to 4,200 kilogrammes per hectare. In most of the other parts of the above-named provinces and districts, further, almost in the whole of Bohemia and Moravia, the hay crop amounts to 2,200 to 2,700 kilogrammes per hectare. The poorest hay crop is in Salzburg, Carniola, in the coast district, in southern Tyrol, and in east Galicia, where it does not amount to more than from 1,400 to 1,800 kilogrammes per hectare.

Rainfall.—In comparison to the above-quoted proportion of crops, the mean quantities of rainfall in the different districts shall be given, expressed in millimetres, and for the four seasons, viz, winter, December to February; spring, March to May; summer, June to August; fall, September to November.

The following figures show the rainfall in the southern part of Tyrol, the central and northern part of Styria and Carinthia, the Böhmerwald Mountains, and the northeastern slope of the Carpathian Mountains:

	Millimetres.
Winter	100-150
Spring	150-200
Summer	300-400
Fall	200-300

According to this the annual quantity of rainfall in the above districts amounts to 750 to 1,050 millimetres.

In lower Styria and south of the Danube, in upper Austria, the rainfall is about the same, only in winter and spring it is somewhat larger, viz:

	Millimetres.
Winter	150-200
Spring	200-300
Summer	300-400
Fall	200-300

The central basin of Bohemia and the low lands of Moravia show the following quantities:

	Millimetres.
Winter	50-100
Spring	100-150
Summer	150-200
Fall	50-100

That is 300 to 550 millimetres per annum.

The greatest summer rainfall, with 500 to 600 millimetres, takes place in Voralberg, on the slopes of the Dachstein Mountains, in upper Austria, and on those of the Predil Mountains (Carinthia and Goriz), while it is smallest in the northern part of Dalmatia, where it only amounts to 100 to 150 millimetres. On an average it may be supposed that the greater quantities of summer rainfall of 300 to 400 millimetres corresponds to the hay crop of 3,000 to 4,000 kilogrammes per hectare, and the smaller quantities of 150 to 200 millimetres to the hay crop of 2,000 to 2,500 kilogrammes per hectare.

In this calculation it must be considered that for the crops of 4,000 kilogrammes per hectare generally a more or less copious irrigation is employed.

Temperature.—The following table shows the mean temperature, in degrees Réaumur, of some of the principal places in Austria:

Towns.	Dec.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Average.
Laybach .....	.95	2.07	.68	3.02	7.80	11.43	14.88	15.74	15.31	12.01	8.65	3.21	7.48
Trieste	4.35	3.53	4.56	6.65	10.84	14.39	18.08	19.36	19.12	15.74	12.47	7.40	11.38
Ragusa	7.97	6.97	7.78	8.96	11.69	14.94	18.18	20.20	20.35	17.96	15.25	11.08	13.44
Bludenz .....	.81	1.04	1.28	3.10	7.37	10.57	12.71	13.80	13.64	11.37	7.84	2.66	6.87
Innsbruck	2.13	2.56	.14	2.85	7.24	10.54	13.02	13.79	13.76	11.13	7.58	1.97	6.45
Ischel	1.21	2.11	.26	1.49	6.30	10.11	12.95	13.76	13.58	10.92	7.39	1.96	6.34
Klagenfurth	3.51	4.86	2.40	1.27	6.85	10.83	14.32	15.08	14.31	11.00	7.18	1.10	5.93
Budweis	1.25	2.21	.61	1.95	6.34	10.03	13.38	14.37	14.08	10.89	6.79	1.46	6.28
Vienna .....	.20	1.35	.63	3.51	8.16	12.54	15.14	16.44	16.10	12.66	8.33	3.43	7.97
Prague .....	.13	1.18	.34	2.71	7.27	11.30	14.78	15.68	15.41	12.21	8.12	2.62	7.43
Lemberg	2.30	3.03	2.15	.78	5.94	11.39	14.77	15.57	15.45	11.37	7.82	1.70	6.44

AREA IRRIGATED.

How great a part of the existing meadows is actually watered by special irrigation can not be ascertained, as no statistics exist on this subject; it may be safely supposed, however, that the area under artificial irrigation does not exceed 10 per cent. of the whole.

Only quite recently attention is beginning to be paid to amelioration of the soil by artificial irrigation, which movement is essentially assisted by the "agricultural offices" that have been established in the different provinces.

Meadow irrigation on a larger scale, although generally in an imperfect state of construction, may be found, for instance, on the Schwarza Creek, on the Pitten River, and on the Fischea Creek in the southern part of lower Austria; in the Mattig Valley in Upper Austria; near Klagenfurth in Carinthia; in the upper and central Lun Valley, as well as in the upper Etsch Valley in Tyrol; further on the farms of Prince Schwarzenberg at Wittingau; at the imperial and royal stud farm at Kladrub; in the Bistritz Valley near Horitz, west of Königgrätz, and in the Elbe Valley, near Pardubitz, in Bohemia.

WATER SUPPLY.

The water required for irrigation purposes is, according to local circumstances, taken either from rivers, creeks, springs, ponds, or other reservoirs.

As a rule the water is conducted from rivers or creeks with its natural head into channels or ditches. This is the case, for instance, in the water conduits from the Sil Creek near Innsbruck, from the Glan River above Klagenfurth, from the Elbe River near Opatovic, south of Königgrätz, in Bohemia, etc. The water course is generally stemmed more or less high, at the place where the conduit is to be started, by a suitable dam, which will cause the water to flow into the irrigation channel. The latter is, at its source or beginning generally provided with a gate, which serves to protect it from floods and to permit of its being laid dry when required.

For the irrigation of comparatively small meadows there are in many places found water wheels for raising the water from the natural water course (creek or river) to the higher border land. These wheels are

suitably mounted and placed in the creek or river, by whose current they are rotated like any common water wheel, and being provided with suitable buckets they raise the water from the river and discharge it into a sluice, by which it is conducted into the irrigating ditches.

Such wheels for raising water are found in large numbers on the Eisack River, in Tyrol, above Bozen.

The rather expensive devices for raising water by machinery are but rarely employed. For irrigating the extensive meadows at Kladrub, in Bohemia, for instance, a 30-centimetre centrifugal pump is put to work, when the Opatovic Canal contains too little or no water. This pump is then operated by a 12 horse-power portable engine, and raises the water from the Elbe River to a height of 5.5 metres.

Wells, tanks, or cisterns are generally employed for the irrigation of kitchen gardens only. Arrangements of this kind may be found in the environs of large cities, especially around Vienna. In this kind of irrigation the water is as a rule pumped from the well, tank, or cistern by means of a horse-power.

Mode of irrigating.—In localities where but small supplies of water are found in creeks or springs, basins or ponds are formed by the erection of suitable dams. The basins thus formed permit the use of a comparatively large quantity of water at a time during the short period when irrigation is required.

Such small basins or ponds have been constructed, for instance, at the trifling cost of 100 florins at Guttaring in Carinthia for the irrigation of a large meadow of 3 hectares, and on the Saager farm in Carinthia for a meadow of 1.7 hectares, when the total cost of construction amounted to only 85 florins. In this latter case the liquid stable manure is also conducted into the irrigation pond for the purpose of giving to the water at the same time a fertilizing effect.

The forming of reservoirs or basins by the suitable damming up of a valley by means of an earth or masonry dam is very frequent in Bohemia. The main object in the construction of such reservoirs and ponds, however, is the promotion of pisciculture, and in some cases also the production of a proper water supply for furnishing power to sawmills, flour mills, and other works. Irrigation from such ponds is here in almost every case only a secondary consideration.

An interesting example of a pond for furnishing water-power is the Archduchess Sofie pond near Pribram, in Bohemia, which is formed by the Pilka earth dam.

Amongst the great earth dams in valleys that of the largest fish-pond, the Rosenberg pond, near Wittingau, in Bohemia, is the most prominent.

On account of the great security and peculiarity of construction of its water outlet the Pilka dam is most instructive. Here the outlet is effected by a line of iron piping in form of a siphon, which is placed in a gallery cut into the solid rock.

By this siphon arrangement the continuity of the earth dam is nowhere interrupted.

Water distribution.—In Austria there exist no special institutions for the supply and distribution of water from the main conduits (canals, etc.,) for irrigation purposes as, for instance, the so-called "water module" in Upper Italy. Such arrangements are not known in Austria for the reason that here no independent enterprise exists for vending quantities of water from canals. The distribution of the water into the different side ditches is effected by simple, mostly wooden, gates, which are raised or lowered according to requirement.

In smaller water conduits still more simple means are employed for regulating the supply. A stone or piece of sod being placed in the narrow ditch is made to act as a dam or gate for obtaining the desired overflow or entrance of the water into the side ditches.

Regarding the distribution of water on meadow land, it must here be mentioned that artificial meadow culture is almost totally discarded in Austria. Where the inclination of the ground permits, that is, where it exceeds $2\frac{1}{2}$ to 3 per cent., the cheap and natural "slope" culture is employed, in which the irrigating ditches are made to follow the formation of the ground, with but a very slight incline of only 2 per cent.

In irrigations of older date ditches with a greater incline are employed, which, however, do not effect as uniform an irrigation as the former.

Where the ground is almost level (incline less than $2\frac{1}{2}$ to 3 per cent.) in exceptional cases only an artificial incline is attempted, otherwise the simple overflow system is employed in forming suitable and shallow basins by small earth dams.

PUBLICATIONS.

Principal information about irrigation and other ameliorations of the soil, carried out within the last decenniums as a rule by the agricultural offices established in the different provinces, may be found in the reports of these offices, as for instance in "general report of the Imperial Royal Agricultural Society of Carinthia," "report of the committee for Lower Austria on the annual information of the agricultural department," "report on the labors of the agricultural office for the Kingdom of Bohemia," "report of the agricultural and engineering office at Budapesth" (Hungary).

General questions of irrigation, the necessary quantities of water, water duties, profiles of canals and reservoirs are treated in "studies on irrigation," by Dr. P. Kresnik, in the *Journal for Agriculture*, edited by Prof. Dr. Henneberg and Prof. Dr. Drechsler, 1881. "General calculations for water profiles and proportions of incline for rivers and canals," by Dr. P. Kresnik (Spielhagen & Schurich), Vienna, 1885. "Safety and utilization devices for water reservoirs," by Dr. P. Kresnik (Spielhagen & Schurich), Vienna, 1889.

Of important works on irrigation in general may be mentioned "Ameliorations of the soil in Bavaria and Hanover," by A. Friedrich Brümi, 1885. "Irrigation in the department Bouches du Rhone," by E. Markus, Vienna, 1886.

Systematic treatises on irrigation and amelioration of the soil in general are found in *Agricultural Hydraulics* and "treatise on technical agriculture," both by Dr. E. Perels, Jena, 1884.

The as yet only projected irrigation of "Marchfeld" plain, near Vienna, is treated in the "project of the irrigation of the Marchfeld," by Podhagsky; further in "agricultural success of the irrigation of the Marchfeld," by F. v. Podhagsky, Vienna, 1877.

Water distribution.—No special industrial enterprise or company existing in Austria for furnishing water for irrigation purposes; special dues, fees, or rents are out of the question. All now existing irrigation systems either belong to private persons or parties for their own use or jointly to several land owners. The respective judicial questions are regulated by the law of May 30, 1869 (Edition of Laws, *Reichs Gesetzblatt* No. 93), on water use, direction, and protection.

Connected with this general state law there exist provincial laws for the 17 provinces.

According to these laws water corporations may be formed by free (unanimous) agreement or by majority resolutions and by order of the competent board of administration for the purpose of carrying out hydraulic constructions, for the protection of property, or for the regulation of water courses; further, for drainage and irrigation purposes.

The resolutions passed by a majority have the consequence that the minority is forced to join the corporation if the board of administration decides that the constructions proposed by the majority are of undeniable benefit and that such constructions can not be carried out to purpose without encroaching upon the territories belonging to the minority. The majority is, however, not decided upon according to number, but by the extent or value of territory. Thus for deciding a question regarding irrigation a majority of more than two-thirds is required, whereas for deciding questions of drainage more than half of the area interested is sufficient for a majority, while for protective and regulation constructions more than one-half of the value of the property to be protected constitutes a majority. In this latter case the eventual increase in value of the property to be protected by the planned constructions is to be taken into calculation.

The corporation causes the construction of the respective work (irrigation for instance), undertakes the care and administration of the same, and the work and fixtures remain the property of said corporation.

A successful impulse to a more numerous formation of water corporations for ameliorating the soil was given by the melioration law of June 30, 1884, according to which, such corporations may receive non-repayable subventions from the State and from the provincial government for said purposes.

These subventions amount to 30 per cent. from the State and 30 per cent. from the province; that is, in all, to 60 per cent. of the total costs of constructions.

The way and manner of employment and distribution of the water is regulated in every irrigation district by special water regulations, and the functions of the respective corporations are governed by special statutes.

QUANTITY OF WATER FOR IRRIGATION.

The quantity of water required for the irrigation of one hectare per second, especially at the time of drought during the period of vegetation, may be fixed at about one litre—that is, 0.001 cubic metre of continual supply. This quantity will be required during the irrigation season of one-half year.

Supposing irrigation to take place once every 2 weeks (14 days of 24 hours), during one day of 24 hours there will be on that day an actual supply of 14 litres of water per hectare.

This latter supply, if supposed stemmed over the surface of one hectare, would amount to a depth of 12 centimetres.

Meadow irrigation, however, as customary in Austria, where and when sufficient quantities are at disposal, is a so-called fertilizing irrigation. In this kind of irrigation a minimum continuous supply of 5 litres per second and per hectare is reckoned upon, and with plenty of water supply even as much as 10 litres and more. The latter is the case especially in spring and fall irrigation, which lasts each from 1 to 2 months without interruption. The quantity of water is also increased before the commencement of the quicker growth of the grass and after it has been mown.

ANTIQUITY OF IRRIGATION.

In the valleys of the mountainous districts meadow irrigation has already been introduced hundreds of years ago; as, for instance, in the Inn Valley in Tyrol. In recent times many of the old irrigation works have been reconstructed and improved according to the rules of science and new irrigation works have been constructed in greater number; as, for instance, the already mentioned irrigation works at Kladrub, Klagenfurth, etc. Irrigation of grain and other fields, which does not as yet exist in Austria (except in the rice fields in the Goriz district), is planned in the proposed irrigation of the Marchfeld plain near Vienna.

The management of all irrigation works is, as before indicated, in the hand of private parties or of corporations.

CANALS.

Special canals for irrigating purposes on a larger scale do not exist in Austria. Here all the existing larger canals have been constructed for leading the water from rivers for industrial purposes. In some instances only these canals are at the same time employed for irrigation.

Among the more important canals of this kind may be mentioned the Opatovic Canal, near Opatovic, south of Königgrätz, in Bohemia, which supplies about 4 cubic metres of water per second. This canal branches off from the right border of the Elba River, which it enters again after a course of 31 kilometres below Semín, near Kladrub. Then there is the Neubach Canal, near Wittingau, in Bohemia, which was built as early as 1585 for the purpose of turning off the floods of the Luschnic River from the great Rosenberg Pond. This canal branches off from the right border of Luschnic River, crosses the rather low divide, and, after a course of 14 kilometres, enters into the Nezarka River.

Finally the Goldbach Canal may be mentioned, which branches off from the left border of the Luschnic River, near Chlumetz, north of Gründ, in Bohemia, and serving principally for supplying numerous ponds, enters again into the same river somewhat above Wessely. This canal is 46 kilometres long and was built in the years 1506 to 1520.

JULIUS GOLDSCHMIDT,

Consul-General.

UNITED STATES CONSULATE-GENERAL,
Vienna, January 8, 1890.

BELGIUM.

REPORT BY CONSUL STEWART, OF ANTWERP.

A report was made in April, 1889, by Engineer Theodore Lebens, director of the service of the irrigation of the Campine at Neerpelt, Belgium, in reply to a demand from Mr. Cotard, vice president of the international congress for the utilization of waters, for information upon the future of canals for irrigation, and I herewith offer the following translation of extracts from said report as being of interest upon this subject:

The principal irrigating canals created in Belgium consist of the network of the canals "de la Campine," which serves the purpose both of navigation and irrigation.

The river Scheldt and its smaller affluents, especially where they are

under the influence of the tide, give rise to abundant irrigation of the land which lies on their course. The river Meuse, and a large number of the running waters of Belgium, have been utilized with an object to benefit agricultural lands.

The construction of the group of waters "de la Campine," serving the purpose of irrigation and transportation by boats, but principally the latter, was commenced before the year 1850, and continued until it was finished in 1865.

The above-named group comprises—

The "Canal de Jonction," from the river Meuse to the river Scheldt, from Maestricht, by the way of Herenthals, to Antwerp, 128½ kilometres in length.

The canal from Hasselt, by way of Turnhout, to connect with the above-described canal near Antwerp, 102 kilometres in length.

A branch, from the principal canal to the canal at Beverloo, 15 kilometres in length.

Another branch (the canalized bed of the river Petite Nèthe), from the above-named principal line to Sierre, 18 kilometres in length.

This shows the group to have a course of navigable and irrigating waters in connection with each other 263½ kilometres in length.

In order to complete the system it would be necessary to canalize the principal water streams of the northeast of Belgium, which could be brought in connection with the existing canals.

The projector of the works which have been executed, Engineer Kummer, now deceased, called attention to this desired object.

The fertilization of the unproductive soil of the northern parts of the provinces of Antwerp and Limbourg can be assured only by the utilization of the waters available from all sources.

The canals were executed by order and at the expense of the Belgian Government, which insures their proper administration and good condition and enjoys the benefit derived therefrom.

The cost of constructing the said navigable and irrigating waterways amounted to over 25,000,000 francs.

The following is given as an average economical result of irrigation per hectare of pasture land :

1. *First expenses.*

	Francs.
Purchase of irrigable moor land	250
Expense of alimentation and evacuation	140
Expense of breaking up the ground	150
Expense of ground works of the parts under immediate influence of irrigation	100
Various tubes and bars for interior distribution of water	30
Manure	350
Sowing	80
Furnishing and planting fifty Canada poplar trees	50

Initial value per hectare of pasture land	1, 150
-------------------------------------------------	--------

Annual results of cultivation.

EXPENSES.

Interest on capital invested, at 4 per cent	46
Ordinary running expenses for keeping in good order	35
Addition of manure	75
Mowing, first hay making, storage of same, and loading same into boat, 3,500 kilometers, at 12 francs per 1,000 kilometers	42
Repairs of barn, insurance, and incidental expenses	28
Total expenses	226

Annual results of cultivation—Continued.

PRODUCTION.

	France.
3,500 kilometers hay, at 70 francs per 1,000 kilometers.....	245
Aftergrowth sold.....	60
Increase in value of the fifty Canada poplar trees.....	30
Total production.....	335

This shows the annual result to be a net profit of 109 francs per hectare.

The expense incurred for establishing connection with the canals, for constructing irrigation trenches, principal and secondary ones, originating at the main canals for the work necessary for the distribution of the water and for the construction of collecting and excavating trenches is borne by the owners of the land benefited thereby.

In the beginning and with an object to popularize the system of irrigation by means of the canals, the Government had the preliminary works to such an end executed at its own expense, afterwards selling the land so improved, without however deriving any important profit from the operation.

Later permissions were granted to owners of land to connect with the canals for irrigating purposes.

The increase in value of the land so improved may be appreciated when irrigable moor land, which was sold for 250 francs per hectare, brought from 2,500 to 3,000 francs after having been subjected to irrigation and general improvements.

Present prices are 30 per cent. below these figures, however.

In establishing the irrigating system of the Campine the Belgian Government had the following objects in view, viz: As an immediate result to procure occupation for the needy classes at a time of want; as a permanent result to favor the production of forage in the Campine, the part of the country where the soil is most unproductive, permitting the raising of cattle on a more extensive scale, and thereby producing manure, which would tend to hasten the fertilization of the naturally barren grounds referred to.

The water which is required to supply the needs of navigation and irrigation in the canals of the Campine is drawn from the river Meuse, near Maestricht, upon Dutch territory.

The following approximative quantities of water are distributed over the irrigated land, in liters, per second and per hectare: In summer, the latter part of June, July, and August, three-fourths liter, and in autumn, winter, and spring (from the early part of October to the early part of June), 3 liters.

At the time when the project of these canals was submitted to the appreciation of the Government, its author, Civil Engineer Kümmer, expected to keep under irrigation, by this means, a surface of 25,000 hectares of moor land.

Unfortunately the limited quantity of water obtainable from the river Meuse, the small extent of the canals, the requirements of navigation, the loss from the canals and other circumstances have not permitted to realize the irrigation of one-tenth of the above surface.

Two thousand and thirty-two hectares are watered from fifty-two trenches established from the canals of the Campine. Ninety-seven hectares are submerged by means of twenty-seven trenches established from the canalized river Petite Nèthe,

As before mentioned, it is the double object of navigation and irrigation, which is the principal cause that the irrigation can not be more effectively extended from the artificial water routes of the Campine.

The agricultural interests should always be guarded in such a manner as to remain unaffected by the special industry of transportation. It will always be difficult, where one object serves two purposes, to obtain full advantages for each.

It is to be feared that, in view of future improvements by all means desirable, tending to cheapen the transportation by the canals, the one of the two purposes they serve has to be sacrificed to the other, and it is evident that this will be the case, in course of time, when the requirements and demands of navigation have become preponderant.

No tax of any kind is collected for the use of the water of the canals for irrigating purposes, and no engagement of any kind exists between the parties interested, *i. e.*, the State and the proprietors of the land under irrigation. Such proprietors have a uniform right to the water available from the canals, the requirements of navigation having been previously satisfied.

Permission to establish trenches from the canals for irrigation are generally granted under certain conditions. They have to be constructed according to plans sent in with the application, and approved by the Government. The applicant will be held to keep the land irrigated under cultivation, and not use it for any other purpose.

In case the Government should find, in course of time, that the public interests require a change in or a demolition of the trenches constructed, with its permission the proprietors of such will be obliged to make the change at their own expense, and without receiving any indemnity for any loss they may thereby incur, or for the work done.

The pamphlet, which is sent under separate cover, contains a copy of the law of the 20th of June, 1855, governing the irrigating system of the Campine. The proprietors are held to abide by any law which may be enacted in the future concerning the subject.

In case of noncompliance with the law any authorization granted may be revoked, and the work done demolished at the owner's expense.

There are many causes which prevent the effective utilization, for fertilizing purposes, of the numerous public and private natural running waters.

1. The unfavorable condition and the state of neglect of these waters.

2. The presence of works or manufactories under water power, formerly installed under unfavorable conditions, on barren ground, in a deserted part of the country, at a time when there was no regular administration or supervision, and in the absence of communication. All local motors were then taken advantage of, no matter how much to the detriment of agriculture the use of such water power may have been.

3. The want of pecuniary resources, and the individual tendency of the inhabitants, although good workmen and sober, to regard every innovation or association with suspicion, and to oppose them.

4. The mode of watering employed. The very abundant and expensive irrigation by means of boards arranged in gutter form, the rectangular form of the trenches, which is an impediment to grazing.

5. The opposition of the inhabitants to any exchange for the purpose of regulating and reconstructing parcels by judicious measurement.

The irrigation by standing water, which was formerly proposed, gives

rise to the same disadvantages. A smaller consumption of water and the fact that the mode is less expensive are in its favor, but as to the quality and quantity of the production of such soil, they are very inferior. This system is little used—only near the banks of the canalized river Petite Nèthe.

Important results could be obtained by arranging for the small running waters, and specially rain water, in such a manner as to collect them in the valleys.

To this end several measures would be necessary.

It is evident that the result would be obtained with more difficulty in parts where there is little declivity of territory than in parts where it is more marked.

In the former case the way of proceeding would be to rectify the stream of the said waters in such a manner as to reduce their course as much as possible, while it would be necessary to give them as much slope as possible; to establish or expropriate any stoppages which may have been made to create water-power for industrial purposes, or at least to arrange the waters in a way to serve both industry and agriculture.

The course of the waters having been rectified as suggested, locks would be established at intervals, so as to check the water and cause it to derive, thereby distributing it over the territory.

The locks would be placed in positions depending upon local circumstances, as the slope, the extent of the course, and the climatical conditions. The alimentation of the irrigated parts may be alternated as circumstances depending upon the same bases may require; the liquid would be gathered up one or several locks lower, checked, and distributed, and again brought back into the trench to be checked.

The system of submersion in streams, already used by Mr. Baurath Hess, of Hanover, and particularly adapted to valleys of slight declivity, has the advantage of being compatible with the disposition of any property, however divided it may be, of requiring little preliminary expenses to prepare it for forage growth, and only little to cover running expenses.

Employing this system, a piece of land of several hectares is surrounded by small ditches, the water to which is brought from the most elevated part of the perimeter, and distributed uniformly by means of small dams, which latter are assisted, if necessary, by small ditches, adapted lengthwise.

When a thorough submersion has been produced, the water which was brought in at the parts most elevated is again evacuated by installations made to that effect at the points situated lowest, thus having the advantages of diversion and running water, without the inconvenience of any geometrical division with boards, trenches, and many other installations for watering purposes, most of them costly.

As above would be the manner of irrigating at times when water is plenty; in the dry season, the summer, it would be necessary to establish a number of small trenches for infiltration.

In the period of the rise of the waters the dams might be dispensed with entirely. In case of heavy rains there is nothing to prevent the keeping of the water so gathered for several days, and to evacuate it afterwards. Only at mowing and hay making time this would not be practicable.

The realization of the foregoing suggestions, of incontestable necessity for the future, could be made possible only under the following conditions:

1. That general syndicates be formed, which, with the aid of subsidies from the State and the province, have the course of the running waters corrected. The general interest would induce such an expenditure and intervention on the part of the authorities.

2. That similar secondary associations be formed, which would defray part of the expenses of correction, on account of the advantages to be derived therefrom, establishing or constructing, according to plans made or approved by the government, such dams, sluices, trenches, as may be required to insure abundant irrigation and evacuation of the waters when required.

The State, the provinces, and the municipalities might in this manner encourage territorial improvements, the benefit of which to agriculture, public health, and the general welfare would be soon felt.

The system of correction of the lines of the smaller streams of water, by far the most numerous, can naturally be applied also to the navigable waters; but, as before stated, the interests of both agriculture and shipping would be better served by keeping them separate.

I need not call attention to the benefit to agriculture which the utilization of the waters for irrigating purposes, such as it was, has occasioned.

That the land properly irrigated and used for pasturage and forage has doubled, and in part, even quadrupled, in value is sufficient proof of this.

From the preceding explanations the following conclusions would result:

Where there is a chance for an active navigation it is always best not to construct canals which are to serve agricultural interests besides those of shipping.

In some cases only it would be possible to conciliate the two interests.

It is undoubtedly forwarding the general welfare to create irrigation canals from the non-navigable running waters. Such disposition of them would insure a drainage where required and the utilization of the waters in the regions where they are needed for fertilizing purposes. The general sanitary condition of the public would be improved thereby, inundations would be less frequent, the rise of the waters could be checked in a measure; in a word, the result would be a considerable gain in agricultural productions and public wealth.

The machinery established upon these waters for industrial purposes, at a time when the necessity of obtaining a motor was preponderant, must be taken away or its disposition changed in a manner not to be an impediment to the effective utilization of the waters of these streams for agricultural purposes.

JOHN A. STEWART,
Consul.

UNITED STATES CONSULATE,
Antwerp, December 6, 1889.

FRANCE.

REPORT BY CONSUL-GENERAL RATHBONE, OF PARIS.

AREA IRRIGATED.

The surface of irrigated lands is roughly estimated at 2,350,000 hectares. As cultivated lands are not generally irrigated, it is not easy to compare non-irrigated with irrigated lands. Pastures are the only lands generally irrigated.

The average production per hectare of irrigated and non-irrigated pastures is—irrigated pastures, 37 quintals; non-irrigated, 31 quintals. This difference of 6 quintals represents a total value in the first case of 230 francs, in the second, of 190 francs, per hectare. Among the areas devoted to cultivating the vine, some are submerged, while others are irrigated. But the value of their product depends upon other causes than irrigation.

WATER SUPPLY.

The canals cut for purposes of irrigation all flow from rivers. In some instances attempts have been made by means of artificial reservoirs to increase the quantity of water yielded by the river. It was for this purpose, for example, that the reservoir of Ordon was constructed in the department of the Hautes-Pyrénées. Its object was to increase the volume of water in the river Neste, from which flows the canal of the same name.

IRRIGATION WORKS.

The number of reservoirs above mentioned is still somewhat limited. The works carried out in view of distributing the water generally consist—

First, of a principal canal, or chief branch, through which the volume of water to be distributed flows from the river; second, of a smaller canal, fed by the principal one; third, of a network of streams, drains, and ditches, which provide each landowner with the quantity of water to which he is entitled.

WATER DISTRIBUTION.

The use of water for irrigating is regulated by the French Code. The articles of the code bearing particularly on this point are the following:

643. The owner of the spring can not change its course when he provides the inhabitants of a commune, village, or hamlet with the water necessary for them, but when the inhabitants have not acquired or prescribed the use of the same the owner may demand a compensation, the exact amount of which is to be fixed by an expert.

644. The owner of a property skirted by a running water which is not national property, according to article 538, has a right to the use of the water for irrigating his lands while it flows past them. The owner of ancestral lands traversed by this water may use it within the full limits of his lands on condition he restores it to its proper bed before it leaves his estate.

645. If a dispute arises between the landowners to whom this water may be useful, the tribunal called upon to give its decision in the matter shall conciliate the interests of agriculture with the respect due to the rights of property, and in every case with the particular and local customs and regulations which pertain to the passage and use of water.

The works executed for purposes of irrigation may be divided into two classes:

(1) Those undertaken and carried out by companies called syndical associations.

(2) Those undertaken and carried out by a contractor.

When a syndical association carries the works into execution its statutes usually determine on what lines the distribution of water shall be regulated. But when the works are taken in hand by a contractor the distribution is fixed either by a decree published after the council of state has recorded its decision, or by a decree signed by the prefect or chief magistrate of the département in which the works have been or are to be executed. The prefect is empowered to sign these decrees since August, 1886.

The syndical associations are composed of landowners whose interests are affected by the want of irrigation. Their powers, privileges, etc., are more or less determined by common law.

The French Senate is at present discussing a projected rural code which will contain a certain number of articles relative to irrigation.

In a general way, the quantity of water required to irrigate a hectare is equal to an out flow of one litre per second all the year round. The cost per hectare is apt to vary considerably if the works are executed by a syndical association. In that case the average cost may be set down at 40 francs per annum for a supply of water equal to about one litre per second. If, on the contrary, the works are carried out by a contractor, the cost is always a fixed one; it can never vary, inasmuch as it has been determined by the deed of concession.

The following table shows the figures of the tax raised for some of the leading irrigating canals:

Canals.	Départements.	Cost.	
		A.	B.
		<i>Francs.</i>	<i>Francs.</i>
Pierrelatte	Drôme, Vaucluse	50	60
Bourne	Drôme	50	60
Véauville	Alpes-Maritimes	80	.....
Verdon	Bouches du Rhône	70	.....
Saint-Mertory	Haute-Saône	35	50

When two figures are given for a single canal, the figures in column A show the tax due by the landowners who subscribed before the water of the principal canal (*see* Irrigation Works) was turned into its destined channel; while the figures in column B denote the amount paid by those who subscribed afterwards. In the case of the last-mentioned canal the figures show, in column A, the sum paid by landowners who subscribed before the deed of concession was promulgated; and in column B the amount paid by those who subscribed after its promulgation.

Springs only may be owned either by private individuals, by the state, or by the small districts called communes. Running waters are considered *res nullius*, but the use of them is regulated according to law on the nonnavigable water courses.

The water of navigable water courses is considered national property.

Although the practice of irrigating is as widely spread in the north as in the south of France, it is chiefly in the regions bordering on the Mediterranean, where the summer rains often fail, that the most impor-

tant irrigating canals have been cut. In the north, east, or west the works designed to promote irrigation are nearly all carried out by private individuals. This is especially the case in the department of the Vosges. In the south they are, for the most part, the result of the combined efforts of a certain number of individuals. They are mainly undertaken where the soil is of a chalky nature, and in lands farmed by alluvion.

Among the systems adopted to distribute the water may be mentioned an interesting one practiced in the department of the Bouches du Rhône. It is a kind of irrigation by submersion. The lands subjected to this method are constantly increasing in extent.

The landowners whose properties are situated on the banks of the Rhône obtain, when they require it, and by means of elevating machines, the quantity of water necessary for the process of submersion, which lasts 69 days and consumes no fewer than 1,500 cubic metres per hectare. The estates in the center of the island of Camargue, in the same department, are less favored than those seated on the river banks. The water has to be conveyed to them from the river by means of small canals and side channels which generally belong to syndical associations of a very remote origin. These side channels work during the rising of the Rhône. As, however, the framework of their flood gates is almost on the same level as the low-water mark of the river, when it is not higher, it often happens that, when the Rhône is low, the side channels become dry. Besides this, the season for submerging the land often coincides with this autumnal fall of the river, and irrigation is practically brought to a standstill.

Numerous plans have been formed to feed these side channels by means of large canals cut in the north of the island. But none of them have yet been carried out. Pending the execution of a plan, a society of landowners, headed by the Count of Chevigné, recently set an example well worth following. Their project is no less remarkable for the way in which it was conceived than for the results which may be expected from it. They are thirteen in number, and their combined estates contain some 1,500 hectares. In order to keep their side channel constantly supplied with water, they applied to several mechanical engineers for machines, and finally adopted an apparatus, presented by one of them, and which has given the most satisfactory results.

Its characteristic feature is that, instead of being a fixture, it floats and can be conveyed from one place to another. Thus it can be made to work anywhere. It consists of a boat built wholly of iron, and equally adapted to fluvial and maritime navigation. Its length is 24 metres, its breadth 5 metres, and its draft of water nearly $1\frac{1}{2}$ metres. It carries three engines on the compound system. The engines are of equal force, placed in juxtaposition, and of 200 horse-power. Two of them each turns a rotary pump by bearing directly on its beam. The third, which can be made to work either of the two pumps, is used only when one of the other engines is out of order. On the one hand these machines are condensing engines, on the other, their steam is provided by boilers on the Bigot system. These latter are used in the French navy, and possess a collective warming surface of 80 square metres. Their consumption of fuel is therefore comparatively small. The pumps fixed up on board are on the Decœur system. They raise the water from a depth varying between $1\frac{1}{2}$ and $2\frac{1}{2}$ metres, according to the level of the Rhone, and distribute the water at the rate of from 750 to 1,500 litres per second.

The following table gives more ample particulars. To understand

its figures rightly, it is necessary to know beforehand that they are given for times when both engines are working together and distributing 500 litres per second.

Height above river.	Horse-power—			Number of turns.	Consumption.	
	In quantity of water brought up.	On the beam of the pump.	On the sucker.		Total per hour.	Per horse-power of water brought up.
1.....	15. 0	24	32	140	35. 20	2. 340
1. 50.....	22. 5	36	48	150	46. 88	2. 348
2.....	30. 0	48	64	160	70. 40	2. 340
2. 50.....	37. 5	60	80	170	88. 00	2. 340

When the pumps distribute 1,500 litres instead of 500, these figures remain proportionately the same. The suction is performed in a special division provided with roses, and the water is thrust back into a collecting pipe which serves for both engines at the same time. While the boat is working it is moored on the spot from which the water is drawn up. The collecting pipe has a weir provided with a flat spout. It runs into a sheet-iron reservoir placed at the head of the side channel and outside the river dam. The connecting of the weir with the collecting pipe is accomplished by means of a link with a hinge to it which enables the spout to remain constantly in position on the edge of the reservoir, whatever the motion of the boat may be. By this arrangement, the work done by the pumps is limited to a height corresponding with the difference in the level of the water, and with that fixed for submerging the land. This second level is slightly below the height of the reservoir itself.

The annual rainfall for all France is estimated at about 77 centimetres.

ANTIQUITY OF IRRIGATION.

The cutting of a certain number of canals for irrigation in the southern districts dates back several centuries. The more important works, however, are of comparatively recent origin. During the last 10 years, especially, a great impulse has been given to the construction of works devoted to irrigation. Subjoined is a list of the most notable enterprises of this kind. It is taken from the "Journal d'agriculture pratique."

Departments.	Description of works.	Cost
		<i>Francs.</i>
Drôme.....	Canal de la Bourne.....	13, 000, 000
Alpes-Maritimes.....	Canal de la Vésubie.....	7, 000, 000
Aude and Hérault.....	Canal to be used for submerging both departments.....	2, 400, 000
Drôme and Vaucluse.....	Canal de Pierrelatte.....	8, 000, 000
Basses-Alpes.....	Canal de Manosque.....	4, 500, 000
Hautes-Alpes.....	Canal de Ventavon.....	2, 000, 000
Aude.....	Canal de Canet.....	1, 000, 000
Bouches-du-Rhône.....	Drying up the Fos marshes, and purifying the waters of the Crau.....	18, 000, 000
Hérault.....	Canal de Gignac.....	4, 200, 000
Loire.....	Canal de Forez.....	7, 000, 000
Alpes-Maritimes.....	Canal de Foulon.....	1, 200, 000
Aude.....	Canal de Cuxac.....	2, 000, 000
Do.....	Canal de Luc.....	} 1, 160, 000
Do.....	Canal de Fabrezan.....	

The public treasury generally contributes one-third of the cost of the works; the landowners interested in them defray the remaining two-thirds. In the case of the most important works, the state, besides contributing its third, has guaranteed for the space of 50 years, to the parties who covered the loan raised for the purpose of carrying out the works, the interest due on the sums lent to the contractor.

J. L. RATHBONE,
Consul-General.

UNITED STATES CONSULATE-GENERAL,
Paris, France, September 6, 1889.

BOUCHES-DU-RHÔNE.

REPORT, IN FIVE PARTS, BY CONSUL TRAIL, OF MARSEILLES, ON

IRRIGATION IN THE DEPARTMENT OF THE BOUCHES-DU-RHÔNE.*

[Based on the Government report of 1875.]

PART I.—PERIERO.

Much attention has been given to irrigation in France during the past century, and the Government has from time to time sought to increase the public interest in this most important subject by publishing scientific reports on the same, and, more recently, by instituting "concoirs" and offering prizes to those adopting the best methods and securing the best results from irrigation. In the north of France irrigation is accomplished by simply inundating the land, and is confined principally to submerging meadow lands in the autumn by turning off large quantities of water from the rivers and streams; in the central portion, by the use of water from springs and wells, distributed over the land by hand and machinery, and in the south, Provence, the Department of the Bouches-du-Rhône, and its neighbors, by irrigating canals. Irrigating canals of any importance are confined to the valley of the Rhône, the foot of the Pyrenees, and to only a few other localities in France. The canals of northern and central France are only used for transportation.

Given sufficient water there is no reason why a canal should not serve for both transportation and irrigation. This is done in Italy with the addition of obtaining motive power from the current as well; but in France the canals only fulfill one function at a time, with but a few exceptions.

The use of canals for irrigation is of very ancient date in France. The first canal in Provence that we know of was constructed by Marius, the consul, in 103 B. C., for the purpose of transporting supplies to the Roman army, then encamped near Arles, and it is probable that it afterwards, when abandoned as a water way, served to irrigate the land contiguous with it. Arthur Young, traveling through Provence towards the close of the last century, was particularly interested in the

* Metric denomination, and their equivalents:

Metre, 39.37 inches.

Hectare, 2.471 acres.

Litre, .908 quart, dry measure.

Litre, 1.056 quarts, liquid measure.

Hectolitre, 2 bushels, 3.35 pecks, dry measure.

Hectolitre, 26.44 gallons, liquid measure.

irrigating canals he there saw and expressed his surprise that other parts of France did not imitate the Midi in this most important of rural economies.

Arrosage of some sort is indispensable in the Midi. Without its aid agriculture would have to be abandoned. Three months and occasionally nine pass by without rainfall. The summers are long and the heat great and continuous, while the sun shines through an intensely clear air, unobscured by a single cloud, subjecting the land day after day to a constant drying and scorching process and causing every particle of humidity to evaporate.

The Department des Bouches du Rhône, to which this report is limited, forms the northeast of France bordering on the Mediterranean, and, as its name implies, comprises the territory surrounding the mouths of the Rhône. Its northern boundary is the river Durance, which rising in the Alps flows westwardly and empties into the Rhône not far below Avignon. From the Durance the irrigating canals are principally drawn. The area of the Department is 510,487 hectares. The entire surface artificially watered embraces 35,091 hectares, and of this the Durance contributes water for 26,880 hectares. Or—

	Hectares.
Irrigation from the Durance.....	26,880
Irrigation from Huveaune, Arc La Touboulu, etc.....	2,911
Irrigation from the Rhône.....	5,300
	<hr/> 35,091

A glance at the map on page 12 of the "Rapport sur le Concours ouvert en 1875" accompanying this report explains why it is that the Durance has been so heavily tapped to supply irrigation for this department.

Provence is composed of mountains, hills, and plains. The greater part of the soil is naturally very poor, it being detritus brought down from the Alps by the Durance, and in flood times spread over the plains. Strong winds sweep over it at times. The soil naturally produces only stunted trees and coarse grasses; but by irrigation and the liberal use of manure a maximum of fertility is obtained where from the want of water absolute sterility reigned.

Geographically speaking, the Department des Bouches du Rhône presents three distinct features. First. A mountainous section to the north and east composed almost entirely of limestone of a dull gray color and in part quite naked of vegetation, and in part covered with wood. Streams from the mountains descend to the Durance, to the Rhône, and to the Mediterranean. Second. Two plains, la Crau, in the center of the department, very stony, and la Camarque, to the west, composed of mud and sand. Third. Marshes and ponds, shallow reservoirs whose waters flow slowly to the sea.

There was an old French proverb that said Provence had three curses to contend with: Parliament, the river Durance, and the mistral. Parliament was swept away by the Revolution. The Durance, whose waters at times overflowed its banks and carried destruction in their wake, has been tamed by man's ingenuity, and from a curse its waters have become a blessing, whilst the mistral, the northwest wind, the great drawback to life in Marseilles and in all Provence, that at times sweeps with terrible force over the country, uprooting trees and destroying buildings, has, owing to the greatly increased humidity of the atmosphere, caused by the irrigations from the Durance, lost much of its former force, is less frequent, and of shorter duration. It

is supposed that the mountains here were once covered with timber, the rainfall regular, and the land fertile; but their denudation of timber deprived the country of a storage for humidity; the rainfall becoming irregular caused the volume of water in the streams to vary greatly; mountain detritus was spread over the formerly fertile plains; the heat and duration of summer became greatly augmented, and the hot air arising from the parched arid earth originated the mistral.

There are five groups of mountains and they take up three-quarters of the department. The topography in this section is the most varied, the mass being twisted into peaks and chains, between which lie valleys, lakes, and ponds. The plains La Crau and La Camarque take up the remaining superficies of the department. They incline slightly towards the sea and the large rivers. La Crau, comprising 35,000 hectares, of which 15,000 are cultivated and irrigated (1875), is formed mainly of pebbles brought down from the Alps in the Glacial period. Before the construction of the Canal de Craponne, La Crau, was one vast uncultivated tract, affording but a scant and coarse pasturage enjoyed in common by the inhabitants. Since the coming of the canal this region has been metamorphosed; rich farms spread over what was once but a desert. La Camarque is that vast delta comprised between the two great branches that the Rhône divides itself into before entering the sea. It keeps growing constantly from the additions made to it by the deposit of matter carried down by the river in suspension. In area it is 88,300 hectares; 50,000 are wild, uncultivated pasturage; 23,000 marshes and ponds, and 15,300 under cultivation. There are several canals in this section, but the figures above show how much remains to be done. The history of the formation of this plain by the river dates back to 400 B. C.

From statistics of 1855 it appears that of the whole area of the department about 7 per cent. is water:

	Hectares.
Ponds and irrigating canals	456. 75
Transportation canals	44. 38
Lagoons	11, 565. 34
Rivers, lakes, streams	23, 270. 64
Total water area	35, 337. 11

Considerable tracts of land, formerly under water, have been reclaimed. In some cases a canal for drawing off the water from swamps and marshes has also been used for irrigation. These reclaimed lands, when properly drained and watered, have proved fertile enough to pay handsomely those who had the foresight to plan and execute the necessary work.

When we come to examine into the quantity and quality of crops grown, and the increase in and of the same, due to irrigation, we are met with the difficulty of statistics that are conflicting and, at times, irreconcilable. Even in the extent of the department we find—

Area of department, statistics of—	Hectares.
1864	512, 232
1867	496, 464
1870	510, 487

a difference for which no explanation is given.

A table of agricultural statistics was prepared by M. Villeneuve in 1820, and one by the government in 1870, which are taken as reliable. It will be seen that both these tables make the departmental area about the same. In 1820 the cultivated land was 169,000 hectares, to 341,000

hectares uncultivated, or as 1 is to 2; while in 1870, if we add the woods to the uncultivated, we have: Cultivated, 201,000 hectares; uncultivated, 309,000, or as 2 is to 3, instead of as 1 is to 2 in 1820, a gain of 32,000 hectares of cultivated land in 50 years, or about 19 per cent. Here are the tables:

Agricultural statistics for 1820.

Cultivated :		Hectares.
Arable land.....	105,000	
Meadows	16,000	
Vineyards	20,000	
Olives	24,000	
Gardens and pleasure ground.....	4,000	
		169,000
Uncultivated :		
Waste land	233,000	
Lagoons and swamps.....	47,000	
Woods, bush, and scrub.....	61,000	
		341,000
Total area	510,000	

Agricultural statistics for 1870.

Wheat.....	70,200	
Rye	390	
Barley.....	1,000	
Oats.....	8,400	
Corn	50	
Seeds and dry vegetables.....	6,650	
Potatoes.....	5,900	
Cabbages, carrots, beets, etc	6,000	
Madder.....	1,490	
Tobacco	80	
Hemp and teasels	980	
Fallow land	20,000	
Arable land.....		121,140
Olives	12,000	
Vineyards	29,300	
Mulberries.....	3,000	
Almonds and other fruits.....	13,000	
Orchards	1,300	
Gardens and pleasure	4,000	
Total tree cultivation		62,600
Meadows dry	3,400	
Meadows irrigated	5,900	
Clover and other fields.....	8,200	
Total grazing and fodder.....		17,500
Woods and forests	87,800	
Willows and wicker	3,200	
Total		91,000
Heath and wild pasture.....	104,860	
Taxable built property	1,800	
Lagoons	35,000	
Marshes	17,000	
Roads, water courses, and uncultivated lands.....	59,587	
Total.....		218,247
Total area		510,487

According to the government report of 1875 it appears that this increase of 32,000 hectares of cultivated land in 50 years was due solely to irrigation, there being about that much more land irrigated in 1870 than there was in 1820.

Statistics in France are not obtainable for periods of more than 15 or 20 years at a time, then a break of a year or two occurs caused by a revolution and a change in the form of government; so that we have no statistics covering very long periods; we have them only in sections.

Taking up the agricultural products somewhat in detail and making a comparison of certain years as obtainable from statistics, we have for cereals, in 1840, 70,312 hectares devoted to their culture, and after a period of 32 years, 1872, 82,223 hectares employed in the same culture. Wheat shows an increase of over 30 per cent.; oats remain about the same; rye, which in 1840, was 2,711, in 1872 falls to 380; barley, in 1840, 4,211 to 2,507 in 1872; corn, in 1840, 56 to 30 in 1872. The table showing an increase in area sown in cereals of 16½ per cent. in 32 years.

	1840.		1840.
	<i>Hectares.</i>		<i>Hectares.</i>
Wheat.....	53,232.00	Madder.....	4,142.00
Maize (wheat and rye).....	1,135.00	Teasels.....	1,112.00
Rye.....	2,711.00	Hemp.....	31.00
Barley.....	4,211.00	Mulberries.....	1,455.00
Oats.....	8,967.00	Natural meadows.....	5,475.43
Corn and millet.....	56.00	Clover and other fields.....	5,470.50
		Pasture land.....	147,289.56
Total cereals.....	70,312.00	Fallow land.....	62,432.00
		Woods (commons and private).....	103,421.00
Vineyards.....	24,991.00	Orchards and plantations.....	6,126.18
Potatoes.....	2,415.00		
Dry Vegetables (beans, etc.).....	2,207.00	Total agricultural area.....	468,097.17
Gardens.....	2,042.00	Roads, water courses, etc.....	49,293.83
Beet root.....	307.00		
Olive.....	24,475.00	Total area.....	512,991.00

	1871.	1872.		1871.	1872.
	<i>Hectares.</i>	<i>Hectares.</i>		<i>Hectares.</i>	<i>Hectares.</i>
Wheat.....	70,858	71,119	Beet.....	129	400
Rye.....	290	380	Madder.....	1,490	1,400
Barley.....	550	2,507	Hemp.....	3	3
Corn (maize).....	40	30	Olive orchards.....	12,000	12,000
Oats.....	7,346	8,187	Vineyards.....	29,397	28,897
			Fallow land.....	23,000	
Total cereals.....		82,223	Natural meadows.....	9,000	
			Clover and other fields (sown).....	10,000	
Dried vegetables (beans, peas, etc.).....	3,509	3,650	Woods and forests*.....	58,000	
Potatoes.....	6,569	5,729	Wild pasturage.....	140,000	
Tobacco.....	100	217	Other lands.....	138,206	
			Total area.....	510,487	

Approximated.

*Woods and forests belong to the department, to public establishments, to communes, and to individual owners.

The increased area devoted to wheat was obtained from cultivating waste land. From 1820 to 1839, 65,000 hectares were annually sown in cereals; from 1840 to 1859 a mean annual of 76,000; from 1860 to 1874 a mean annual acreage of over 78,000.

As for the yield of wheat per hectare, it varies not only on different farms but on the same farm in different years. A good year returns about 15 hectoliters to the hectare, or about 16½ bushels to the acre. In 1868 the yield per hectare was only 8.05 hectoliters, or about 9 bushels to the acre. The wheat—winter wheat almost exclusively—is sown two consecutive years on the same land, which is then given a year's rest,

Of fallow land—arable land permitted to lie idle—there was in the department, in 1840, 60,000 hectares; in 1852 this had fallen to 29,000, and since 1862 to less than 23,000. The jury who examined the irrigated farms in 1875 and awarded the prizes * state in the “rapport” that the disappearance of idle land is due to irrigation.

The statistics for the cereals, 1860–74, 15 years, referred to above, are:

Area sown with cereals, 1860–1874.

[In hectares.]

Years.	Wheat.	Rye.	Barley.	Maize.	Oats.	Total.
1860.....	78,900	1,294	1,937	.....	9,000	91,131
1861.....	63,054	515	1,044	.....	8,066	72,679
1862.....	61,652	649	1,039	.....	7,557	70,897
1863.....	62,539	646	2,072	.....	7,891	73,148
1864.....	67,040	665	1,075	.....	6,717	75,497
1865.....	63,875	462	1,200	.....	8,886	74,423
1866.....	67,418	648	2,133	.....	8,042	78,241
1867.....	70,100	350	500	.....	8,500	79,450
1868.....	68,200	300	500	.....	8,100	77,100
1869.....	70,000	300	492	.....	8,100	78,892
1870*.....	.....	.....	.....	.....	.....	.....
1871.....	70,858	290	550	40	7,346	79,084
1872.....	71,119	380	2,507	30	8,187	82,523
1873.....	69,975	450	595	65	11,431	82,516
1874.....	68,775	430	598	70	6,562	76,365
Average of fifteen years.....	68,107	527	1,160	51	8,170	78,015

*No statistics by reason of the war.

Cereal crop for 1860–1874.

[In hectoliters.]

Years.	Wheat.		Rye.		Barley.		Oats.	
	Aggre- gate.	Perhec- tare.	Aggre- gate.	Perhec- tare.	Aggre- gate.	Perhec- tare.	Aggre- gate.	Perhec- tare.
1860.....	1,218,353	15.43	11,888	9.20	41,916	21.65	180,000	20
1861.....	731,426	11.60	5,834	11.83	5,971	5.72	141,558	17.55
1862.....	600,490	9.74	7,353	11.33	16,886	16.25	115,547	16.28
1863.....	750,458	11.43	5,943	8.93	38,559	18.60	133,674	18.04
1864.....	905,040	13.50	8,795	12.22	19,511	18.15	134,407	20.04
1865.....	818,878	12.82	6,929	15	21,448	18.03	176,920	19.91
1866.....	968,122	14.36	9,849	15.20	30,812	14.44	141,459	17.59
1867.....	829,994	11.84	5,320	15.20	7,310	14.62	159,800	18.80
1868.....	551,055	8.05	3,990	13.30	5,950	11.00	110,578	13.65
1869.....	933,100	13.33	4,500	15	10,627	21.60	110,573	13.65
1870*.....	.....	.....	.....	.....	.....	.....	.....	.....
1871.....	1,159,945	15.64	3,520	12.14	11,880	21.60	189,522	25.80
1872.....	1,101,795	15.50	4,856	12.78	44,488	17.74	195,424	23.87
1873.....	984,548	14.07	5,301	11.78	6,878	11.55	817,085	27.74
1874.....	1,152,732	16.75	6,536	15.20	8,999	15.05	196,909	30
Average crop per hectare.....	.....	13.14	.....	12.61	.....	16.20	.....	20.06

* No statistics by reason of the war.

The other more important products of the department are: Potatoes, vegetables, dried and fresh; the olive, vine, fruits, and tobacco. In

* The prizes referred to were offered by the French Government in 1875 to encourage the advancement of agriculture by irrigation. First prize, farm of over 4 hectares showing best results from irrigation, a gold medal and 1,000 francs; second, 700 francs; third, 600 francs. For farms of less than 4 hectares: First prize, gold medal and 600 francs; second, 500 francs; third, 300 francs. A silver medal accompanied the second prizes and a bronze one the third. It was intended that the “concours” should last for 5 years, but it seems that it was given up after 2 years. The first year 39 farmers contended for the prizes, and the “jury” who visited their farms made a brief report on each one. Their report is to be found in the “rapport” for 1875 that accompanies this brief investigation.

their cultivation *arrosage* from the canals is being used more and more every year, as will appear later on.

For potatoes we have:

	Hectares.
1840	2,415
1852	3,446
1861	6,569
1872	5,729

No statistics as to yield per hectare.

For dried vegetables, beans, peas, lentils:

	Hectares.
1840	2,207
1852	2,608
1862	3,407
1871	3,509
1872	3,650

Fresh vegetables, market gardening in 1862, 4,117 hectares. Since that time the raising of "primeurs" for the London, Paris, and Marseilles markets has greatly increased, so that the acreage now given to fresh vegetables exceeds 6,000 hectares.

The olive fell off from 24,000 hectares in 1840 to half that figure in 1872. This was caused by the large importation of Italian olive-oil and also to serious losses sustained by the French olive farmers, due to a succession of heavy frosts.

The vine has experienced many vicissitudes and shows great fluctuations.

	Hectares.
1840	24,991
1855	44,069
1869	61,303
1872	28,897

The old method of sowing wheat, etc., in the spaces, 1 to 2 metres, between the rows of vines is now regarded as very bad farming; neither harvest being up to the full yield, and the land is rapidly impoverished by the double work exacted of it. In 1866 a new enemy of the vine made its appearance in Vaucluse, and from thence gradually spread over the greater part of France, threatening the total destruction of vine culture. This was the phylloxera, a microscopically small bug, prodigiously fecund, multiplying itself by myriads in the roots of the affected vines and exhausting the sap until the plant died. This insect after destroying one vineyard migrates to the next to continue its work. Various expedients were tried to kill the enemy, the object being to find some substance that mixed with the earth would destroy the insect without injury to the vine; but these efforts were not crowned with complete success.

A viticulteur, M. Faucon, of the Bouches du Rhône, conceived the idea of drowning the pest, and it now appears that if the afflicted vines are submerged under water for a sufficiently long time they are completely freed from it. M. Faucon submerged his vines for thirty consecutive days immediately after the vintage and killed the phylloxera without injuring the vine. The quantity of water necessary to submerge a vineyard depends on the permeability of the soil; about 864 cubic metres of water every 24 hours for each hectare was sufficient in M. Faucon's case. The earth must be completely saturated to the depth of the roots; the submersion being accomplished, the vines should be pruned and manured; this, of course, in the autumn after the vintage.

Among fruits the almond has been increasing in favor steadily since 1860. From 1,500 hectares in 1860 the number went up to 7,000 in 1870.

Other plantations of less extent and importance are: Figs, capers, jujube, pistache, peach, apple, pears, cherries, apricots, grenadine, medlars, quince, walnut, prune, and agerole. Most of these orchards are planted in arable land. Much greater care and study is required for irrigating with good results the larger fruit trees than is necessary with the cereals and vegetables.

In 1863 there were 752 farmers who raised 183,500 kilos of tobacco on 124 hectares, which the government report of 1875 says paid them 945 francs per hectare, or about \$90 per acre. In 1875 there were only 265 farmers raising tobacco on 43 hectares. These are the last statistics; none as to cost of production. Heavy manuring and frequent *arroage* are required. The decline in tobacco production is partly explained by governmental interference. A special permit must be obtained to raise it, and the government specifies the kind of tobacco to be grown. It can be sold only to certain persons and at a fixed price—all under government regulation. Its production in this department is unimportant.

One is led to compare southern California with Provence. The first has a milder average climate and a richer soil, enabling it to produce even a greater variety of fruits, in addition to the cereals, than southern France. It is stated that the counties of Los Angeles, Santa Barbara, Ventura, San Bernardino, and San Diego are alone capable of producing all the figs, grapes, olives, oranges, lemons, nuts, and prunes imported from France, Spain, and Italy.

When land there is improved with bearing vines and fruit trees it brings from \$100 to \$500 per acre, while unimproved land can be had for one-fifth that price. Unimproved land in southern France means nonirrigable land, and can be had for \$15 per acre, while lands of identically the same soil that are irrigated, bring \$500 per acre; devoted to the olive, small fruit, etc. These are the land values given by M. Menestrel in 1882, and it seems they are about the same to-day.

Southern California presents a similar climate, better soil doing away with or greatly lessening the use of manure, one of the heaviest items in French farming and needing but one thing—irrigation—to make the whole country as productive as the very choicest sections now are and capable of supporting an immense population. The most important question for southern California is irrigation, a rural economy that has been studied and successfully practiced here for centuries.

While the cereals seem to be suited to large farming (*la grande culture*), the vine, olive, small fruits, etc., pay better when produced on a small scale (*la petite culture*). Southern California should be divided up into thousands of small fruit farms. French properties of this sort are frequently not more than 20 acres, sometimes much less, that being all the land one average family can cultivate without the employment of hired labor. The products of such a farm are raised on small patches. One frequently sees but 1 acre given to wheat, another to the vine or olive, several for gardening, and the remainder in pasture on a 10 or 15 acre farm. This diversity of production prevents the farm work from being overexacting at any one period, enabling the family to work on the different crops at different times, and keeping it busy all the year round. Besides, it is found, even on these small farms, that marked differences in the soil occur, so that experience has taught that it is more profitable to divide up 10 acres in several cultures than to confine them

to but one. These small farms require little or no machinery in the American sense of the word.

Southern California should be covered with a network of irrigating canals as is the Bouches-du-Rhône. It appears that the Santa Anna is tapped to such an extent that in summer the river bed is perfectly dry and the irrigating value of its waters quite limited. By the construction of reservoirs for the storage of the waters that are allowed to escape to the sea in winter the irrigable area can be increased to any desired extent.

It is interesting to note that just as the water supply for arrosage in the Midi was and is managed by companies, so we read in the San Bernardino Times that—

The Ontario Land Company has driven a tunnel in under San Antonio Creek, a distance of nearly 1,800 feet, at a cost of about \$52,000, and they have about 250 inches of water, worth a quarter of a million dollars.

PART II.—IRRIGATING CANALS—THEIR ORIGIN AND MANAGEMENT.

As far back as when France was under Roman rule that part of it lying between the Durance and the sea presented a surface so irregular, a water supply so uncertain, and a soil so arid that the inhabitants, in order to insure their continued existence there, were forced to turn their attention to irrigation, even at that early period, so they dug canals to conduct the waters of the Durance southward, to Arles and Salon. Some of these existed in the twelfth century, but were afterwards destroyed during the wars of invasion.

The Department of the Bouches-du-Rhône offered all the difficulties imaginable in connection with the supply, control, and distribution of water. The Alps furnish an ample supply, but it came in torrents, or not at all; a succession of floods and droughts. The Durance that carried the melted snow and ice to the sea had to be confined within its banks, the sea at times encroached upon the land, and in the interior were large marshy tracts that had to be drained, and there were other tracts, where no streams were to be found, that had to be irrigated. To correct these natural errors, associations of individuals, called syndicates, were formed. They obtained permission from the general Government to protect themselves from the water where there was too much, and to supply themselves with it from the large rivers where there was little or none at all.

These associations were divided into syndicates:

First, for defense against the sea; second, for defense against the rivers; third, to drain lagoons, marshes, etc.; fourth, to irrigate the land.

In 1875 there were only two syndicates for defense against the sea existing, with their headquarters at Arles. They protect only a short coast line and are not very important.

For defense against the rivers: Against the ravages of the Durance and the inundations of the Rhône there were fourteen syndicates, composed of proprietors whose lands are contiguous to the rivers, who contribute to the expense of embankment, etc., according to the magnitude of their respective interests, the state likewise lending a hand.

The concessions enjoyed by these associations were granted by the general Government through its minister of public works.

Each association is governed by a syndic composed of five members appointed by the préfet of the department, and selected from among the most important (*i. e.*, paying the most taxes) landlords. This board

changes every year by the retirement of one member and the appointment of a successor. One of the syndic is named as director by the préfet. The director is president of the board, calls the meetings, and has general charge of the affairs of the association. The engineer of the arrondissement has charge of the works. As the entire syndic is appointed by the préfet, it will be seen that the Government has complete control of the association.

The associations syndicales of the department for drainage are 53 in number, and for irrigation, 81. The formation and government of these syndicates have varied from time to time. From 1805 to 1851, it appears, they elected their own officers and managed their affairs themselves. From 1851 to 1865 the syndics were appointed by the préfet, and their resolutions, to be effective, had to receive the approval of the préfet. In 1865 a new law was made authorizing two kinds of associations, the one free and the other under Government control, the latter to enjoy certain privileges in the levying of assessments and in the condemnation of property for the use of the association.

The Government report says "the election of the syndics by those interested is greatly desired," *i. e.*, they should be free from governmental intervention. On the other hand, when the work was one calling for a large outlay of capital, as the canals at Marseilles, des Alpines, and others, the private parties who began them were almost universally ruined, and the enterprises had to pass through a number of hands before the completion of the work. It may be as well to remark here that while the benefit to the Midi from the canals has been inestimable, the canals themselves have been managed in such a way as in only a very few cases have they been desirable investments, many of them being conducted for years at a heavy loss. It seems that the French farmer is a hard customer to deal with. He uses the canal for irrigating his land, refuses in many cases to pay for it, and disputes arise between the companies and farmers that are carried to the courts, involving great expense in both time and money before they are settled.

The inhabitants of the Bouches-du-Rhône have conducted the fertilizing waters of both the Durance and the Rhône to lands formerly abandoned to an eternal sterility, and by draining the marshes and swamps have added that much additional territory to their department and have made that addition salubrious and inhabitable.

The work is almost accomplished to-day. What is now required is its careful maintenance. This is the principal task of the associations syndicales.

Among these 81 irrigating canals the most important are the Canal de Craponne, and des Alpines, and de Marseille, differing from the other canals in many respects, and all taken from the Durance. As this river supplies by far the greater part of the water employed to irrigate the department, some additional facts concerning it may not come amiss. Its length, then, in the Department between the Verdun and the Rhône is 96 kilometres. It is a torrential stream with a fall of from 3 metres per kilometre in the upper part to one of 2 metres per kilometre in the lower. In volume it varies from 40 to 6,000 cubic metres per second. Its greatest rise (*crue*) was that of November 2, 1843, when it reached 6.20 metres at the bridge of Mirabeau. The average volume of water is 106 cubic metres. The river is fullest in winter and spring, when its waters are not much needed, and runs very low in summer and autumn during the period of irrigation.

The problem there is not simply the diversion of the water from the river as it happens to flow, but the storage of the flood waters of win-

ter and spring, so that the supply may not fail when it is most needed. This is the question, it seems to me, that calls for most study in California, not simply the construction of canals and ditches, but of canals with reservoirs and basins of such size and location as will furnish a regular water supply for the entire irrigating season.

As the Durance comes rushing down from the mountains in winter it spreads over a very large surface, four or five times larger than a river of its volume takes if confined within its banks, changes its bed if left to itself, carrying pebbles and sand over fertile fields and rendering them valueless. The *syndicats de défense* now prevent this. For the expense of embankment the state contributes one-third, the department one-sixth, the *syndicats* one-half, and the work is in charge of the engineers of the department.

The river at the Pont de Mirabeau, where observations are made, showed that the amount of mud carried down the river in suspension at that point in the summer and winter was :

Weight of mud obtained in 10,000 liters of water.

Years.	Summer.*	Winter.†
	<i>Kilos.</i>	<i>Kilos.</i>
1867.....	10	8
1868.....	45	25
1869.....	9	10
1870.....	19	22
1871.....	10	16
1872.....	15	30
1873.....	11	24
1874.....	12	21
Average.....	16.4	19.6

*April 1 to September 30.

†October 1 to March 31.

These weights are obtained from a measure of muddy water, first drained of the water and then dried in a kiln at 100° C.

While the pebbles and sand are very injurious to the land, the mud carried along in suspension is regarded as of great fertility, and the muddy water is turned on to cover the fields to enrich them. The water is used for this purpose when yellow in color, dark-brown and red being considered pernicious.

An analysis of the river mud, made of the same taken from two somewhat distant points of the river, shows :

Analyses.	Capit Ville Lomé Vaucluse.	Dépôt du Canal des Alpes.
Physical:	<i>Per cent.</i>	<i>Per cent.</i>
Sand.....	27.70	50.50
Impalpable sand.....	72.30	49.50
Total.....	100.00	100.00
Chemical:		
Part not affected by <i>aqua regale</i> , calcined.....	45.210	47.280
Carbonate of lime.....	44.050	43.580
Carbonate of magnesia.....	1.413	1.040
Potash.....	.188	.072
Sesquioxide of iron.....	3.680	5.925
Aluminum.....	2.070	1.489
Water in combination with sesquioxide.....	1.368	1.555
Phosphoric acid.....	.020	.021
Organic matter.....	1.971	.038
Total.....	100.000	100.000

THE CANAL DE CRAPPONNE.

The Durance spreads its fertilizing waters over the plains and valleys of Provence principally by these canals—de Craponne, des Alpines, and de Marseille. These canals are celebrated the world over for their age, the benefit they have conferred upon agriculture, and for the skill and daring displayed in their construction.

The Canal de Craponne is taken from the Durance between St. Estève Janson and La Roque d'Atheron, 150 metres above the level of the sea. From this point to Lamanon, where the canal subdivides into two principal branches, its length is 22,995 metres and its fall 30.72 metres. From the distributing basin of Lamanon one branch goes to Salon, where it divides into two arms, one of which goes towards Gans and La Touloubre for a distance of 9 kilometres, the other towards Pelissanne, Langen, and Cornillon, to discharge itself, after a course of 23 kilometres, into the Lagoon de Berre in the neighborhood of St. Chamas. The difference in level between Lamanon and St. Chamas is 90 metres. The second branch, called the Branch d'Arles, crosses la Crau from the east to the west and empties into the Rhône at Arles, after a course of 45,138 metres and a fall of 105.90 metres.

From the Arles branch an arm separates below Eyguieres, proceeds southward to empty into the Lagoon de Berre near Istres. This arm has a length of 45 kilometres and a fall of 70 metres.

The canal takes its name from Adam de Craponne, who in 1554 was granted a concession to take the waters of the river Durance and use them as to him seemed best. He was a young man of noble family and the most distinguished engineer of the period, and in his effort to construct and complete the canal he devoted his life and spent the whole of his large fortune, finally contracting enormous debts to carry on the enterprise and ending in hopeless bankruptcy. His reputation as an engineer was so high that the King sent him to Nantes to examine the fortifications there being built by the royal engineers, and upon his reporting to his majesty that the work was inferior in every respect through jobbery and corruption, he was poisoned by His Majesty's servants, whose feelings had been hurt by his criticisms. This in 1575. In 1854 a statue of the great engineer was unveiled at Salon to honor his memory—

Du compatriote illustre qui a répandu, avec les seules ressources de son génie et de sa fortune, la fertilité et la richesse dans l'aride Crau et dans tant de contrées ou regnaient la stérilité et la misère.

To fill the canal bed with water M. de Craponne made a lateral opening (*prise*) on the left bank of the river, as large as the normal width of the river at that point and so arranged as to secure a flow of water all the year round. The plan adopted by him three centuries ago has not been improved on since. The water is turned or forced into the canal by the aid of floating bars 60 centimetres in depth. These bars are made of layers of small stones and fagots bound together and strengthened with transverse pieces of wood. Trunks of trees are secured to the lower part of the bars and they are held in place by being firmly attached to posts driven deep into the river bed. The bars are placed obliquely to the current of the stream. This work, of course, requires constant mending; but as the materials are cheap, it is principally a question of proper construction and arrangement. The cost of the bars is given as 12,000 francs per annum.

In 1571 Craponne had spent his entire fortune on the canal, and in addition had contracted an enormous indebtedness, and no one coming to his rescue his creditors took the canal and associated themselves

together under the name L'Œuvre de Salon. After Crapponne's death the Ravel brothers, of Salon, obtained from his heirs, who, it seems, still had a certain interest in the original concession, the right to construct a branch canal from Lamanon to Arles. In 1583 these Ravel brothers and the creditors, *i. e.*, the association L'Œuvre de Salon, combined their interests and the administration of the canal was managed by these two sets of proprietors, whose shares and votes are given in the following table. It is interesting to note that it was the mill-owners who secured possession of the canal to use it for water power, while the farmers were either too poor to put money into it or too ignorant to appreciate what it would do for them and so did not interest themselves about it. The canal was managed by a syndic elected by the shareholders. This corporation was free from government control, and the successors of the original shareholders manage its affairs now in about the same way the syndic of 1583 did. According to the Government report the canal has been always badly managed, with a long list of lawsuits, and has caused the public administration no end of trouble. The whole area effectively irrigated by the canal and its branches amounts to 10,000 hectares. Here are the tables referred to above:

ŒUVRE DE SALON.

Description.	Shares.*	Votes.
	<i>Ecus. s. d.</i>	
The Mill de Lançon	230	2
The Mill des Quatre Tournants	385	4
The Mill d'Eygnières	151 21 2	1
The Mill de Mallemort	50	1
The Mill d'Alleins	20	1
The Town of Salon Grès and Vionges for irrigating	60	}
The Proprietor of Grès	25	
The Commune of Alleins, irrigation	30	
The Hospital of Ste. Martha, D'Avignon, for irrigating Miramas and St. Chamas ..	30	
	981 21 2	9

ŒUVRE D'ARLES.

The mills and irrigation, Arles	1, 084 29	63
The Corps des Arroseurs de la Crau d'Arles for irrigating Bois-Vert	17 31	1
The Mill de Chambremont	58	1
Total	1, 100 12	9

* Values of 1583.

The cost for irrigation from one of the branches of this canal for the season April to October, 6 hours a week, per hectare, was:

	<i>Francs.</i>
For gardens	19.52
For meadows	13.02
For orchards	6.12

This was the rate established by the company in 1802, and it appears that the company endeavored to increase it at different times, and in 1875 the tribunal of Tarascon decided that the rates of 1802 were all that the company was entitled to demand.

Without entering into details concerning the Canal des Alpines, which is taken from the Durance at Mallemort, using 22 cubic meters of water per second, with a length of 313 kilometres, irrigating 8,000 hectares, and resembling the Canal de Crapponne, we come to

THE CANAL DE MARSEILLE.

The Canal de Marseille is the most important of all the canals in France, because it not only furnishes water for irrigating the country and power for mills and factories, but in addition it supplies a city of nearly 400,000 inhabitants with a constant and ample supply of good water, and it pays a dividend of about 3 per cent. on the original outlay.

It was plainly seen in the middle of the last century that the streams in the immediate vicinity of Marseilles would not furnish sufficient water to the city if it continued to increase in population, so that, attention being forced to this matter, a concession was obtained to conduct a part of the Durance to Marseilles. Efforts to accomplish the work were made by private parties in 1770, 1818, and 1834; but without success. At last in 1837 the municipal council of the city undertook the work, and intrusted its execution to M. de Montricher, a distinguished engineer, and in 1848 the work was completed.

The volume of water taken from the Durance is 9,000 litres per second, the river being tapped near Pertuis at an elevation above the sea of 187.25 millimetres. The general course of the canal is south and west until what remains of it is finally discharged into the sea. The length of the main canal is 125 kilometres, and its principal branches make 34 kilometres more. The length of all the irrigating ditches for what is called periodic water (that used from April to October) is 230 kilometers, the length of closed conduits for distributing water taken from the canal all the year round (*eau continue*) is 275 kilometers in the country and 180 in the city. The number of permits for irrigating from April to October is 2,063; for the continued use of water in the county 5,700, for its continued use in the city 8,500; besides which the falls of the canal supply power for 107 mills and factories, the force being equivalent to 1,502 horse-power. Each concessionaire of irrigating water is allowed to turn it on 6 hours per week, subject to a time regulation so arranged as to make the drain in the canal at a certain point and time as light as possible.

The cost of the canal to date (1875), including expenditures of every description, purchase of land, construction, reservoirs, basins, tunnels, aqueducts, and distribution in country and city, amounts to 44,820,000 francs.

The receipts for 1876 were:

	France.
City permits	335, 000
Rural permits	625, 000
Power permits	408, 000
First expense of introduction paid by new subscribers	115, 000
Total	1, 483, 000

The concession of 9,000 litres taken from the Durance is disposed of as follows:

	Liters.
For the Commune d'Aubagne	1, 000
For the city (Marseilles) and for purifying the harbor	2, 500
For the Falls of l'Huveaune, le Janet, and the Aygualudes (streams)	500
For watering streets	250
For <i>eau continue</i> (water used all the year)	450
For irrigation	2, 916
For loss by infiltration, evaporation, about one-tenth	884
Total	8, 500

Leaving 500 litres to be disposed of which now runs into the sea.

The canal and its branches, as it proceeds from the river to the sea, passes through a very uneven country. For 16 kilometres it is carried under tunnels, three in number; then it is carried across rivers and over valleys and ravines by means of aqueducts, viaducts, and siphons.

The most important of these works is the aqueduct of Boquetavours, which required 6 years in building. It is composed of eighty arches in three tiers, with the following dimensions:

	Metre.
Total length of aqueduct.....	382.00
Height.....	82.65
Width at the base of the pillars.....	13.00
Width at the top of the pillars.....	4.50
Width of the water course or channel.....	2.20
Depth of water in channel.....	2.40

Tier.	No. of arches.	Space of arch.
First.....	12	15
Second.....	15	18
Third.....	53	5

Fall or inclination of aqueduct per metre, .004 metres.

The aqueduct is about 30 kilometres from Marseilles, and is justly regarded as one of the most interesting points to visit in France.

The basin of Realtort, where the canal water is filtrated and made unobjectionable for drinking purposes, is another work demanding attention. It covers 28 hectares and has a capacity of 2,300,000 cubic metres. By means of this basin and its appliances all the mud and sediment are extracted from the water, so that it enters Marseilles in a perfectly clear state.

The regulation adopted by the municipal council concerning the use of the Marseilles Canal water shows that it was decided in 1853 that the concessions or permits should run for 50 years from that time and that all permits should expire in 1903; that a concession for irrigation should be granted upon the payment of the expenses incurred in making the ditches and an annual rent to conform to the annexed tariff.

Quantity of water per second.	Cost of the ditches.	Annual rent.
<i>Litres.</i>	<i>Francs.</i>	<i>Francs.</i>
100	400	80
50	200	46

No permit is given for less than half a litre per second.

For water in the country, to be used all the year, the tariff is:

Quantity of water—		Cost of conduits or pipes.	Annual rent.
In modules.	In litres, per 24 hours.		
2.00	17,280	<i>Francs.</i>	<i>Francs.</i>
1.00	8,640	500	190
.50	4,320	250	115
.20	1,728	125	72
.10	864	65	44
		35	27

Permits for two-tenths of a module are only granted to proprietors whose lands are less than 20 ares (an are is 119.6 square yards), and of one-tenth of a module to those whose properties are 10 ares or less.

For the city and its suburbs, for the use of eau, continue the tariffs:

Quantity of water—		Cost of pipes.	Annual rent.
In modules, a decilitre per second.	In litres, per 24 hours.		
1.00	8,640	<i>Franks.</i> 1,000	<i>Franks.</i> 100
.90	7,776	910	91
.80	6,912	820	82
.70	6,048	730	73
.60	5,184	640	64
.50	4,320	550	55
.40	3,456	460	46
.30	2,592	370	37
.20	1,728	280	28
.10	864	190	19
.05	432	150	30

The annual rent for each horse-power is 275 francs for a fall of water from the canal and its branches. One horse-power is represented by a volume of 100 litres of water per second falling from a height of a metre.

This is the only canal, as far as I can discover, in the department that pays any return on the original outlay. Before the city undertook its construction it carefully canvassed the country through which it would pass and thus secured in advance enough subscribers to make it a financial success.

PART III.—WEATHER OBSERVATIONS.*

To better understand the climate of the Midi, and more particularly that of Marseilles, I have obtained from the observatory some statistics concerning the temperature, rain, and winds. The tables given below on temperature and rain cover a period of 66 years, or from 1823 to 1888; that on winds a period of 15 years, or 1874 to 1888. Prior to 1865 the observations were taken at the old observatory under one set of conditions. Subsequent to that date they have been taken at the new observatory under dissimilar circumstances, the altitude and time not being the same. From 1823 to 1855 the maximum temperature was taken at 3 p. m. This should be increased by 1.16°; to give the true maximum.

The tables show us that the climate is a very even one from year to year.

Monthly averages of temperatures in the Département des Bouches du-Rhône.

MAXIMA.

[Degrees centigrade. Formula: Fahrenheit = 9 $\frac{\text{centigrades}}{5}$ + 32.]

	Jan.	Feb.	March.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1823 to 1832.	9.23	11.52	14.00	17.54	20.68	23.42	26.48	25.99	23.35	19.25	14.33	11.61
1833 to 1855.	10.82	11.81	13.68	16.67	20.89	24.88	26.59	26.51	23.42	19.33	14.44	11.31
1856 to 1865.	10.96	11.52	14.00	17.81	21.37	25.25	27.73	27.28	24.28	20.65	14.79	11.74
1866 to 1888.	11.40	13.34	14.95	18.10	21.93	25.36	28.16	27.84	24.86	19.65	14.90	11.50

* Thermométrique, pluviométrique, and ventose taken at the Marseilles Observatory.

Monthly averages of temperatures in the Département des Bouches du Rhône—Continued.

MINIMA.

1823 to 1832	2.72	4.28	6.11	9.17	12.34	14.80	17.83	17.18	18.09	11.67	7.86	5.49
1833 to 1835	3.29	3.58	4.77	7.81	11.71	15.53	17.41	17.21	14.71	11.34	6.93	3.79
1836 to 1865	3.06	3.32	5.69	9.17	12.22	15.67	17.94	17.76	15.06	12.36	6.96	3.90
1866 to 1888	2.51	3.85	4.80	7.74	10.70	14.01	16.29	15.89	13.87	9.64	5.69	2.97

MEAN.

1823 to 1832	5.98	7.90	10.06	13.33	16.56	19.11	22.16	21.59	19.22	15.46	11.09	8.55
1833 to 1835	7.05	7.70	9.22	12.24	16.30	20.20	21.99	21.87	19.07	15.34	10.68	7.55
1836 to 1865	7.01	7.42	9.85	13.46	16.79	20.47	22.83	21.51	19.66	16.32	10.89	7.92
1866 to 1888	6.96	8.60	9.91	12.92	16.32	19.68	22.22	21.86	19.36	14.64	10.30	7.28

Mean annual temperature.

ANCIEN OBSERVATOIRE.

[Degrees centigrade.]

Year.	Mean temperature.	Year.	Mean temperature.	Year.	Mean temperature.	Year.	Mean temperature.
	°		°		°		°
1823	14.34	1834	15.04	1845	14.20	1856	14.55
1824	14.38	1835	13.42	1846	15.46	1857	14.36
1825	14.43	1836	43.29	1847	14.48	1858	14.17
1826	14.36	1837	13.10	1848	14.44	1859	14.88
1827	13.82	1838	13.42	1849	14.54	1860	13.70
1828	15.07	1839	14.04	1850	13.99	1861	15.21
1829	12.95	1840	13.70	1851	13.58	1862	14.77
1830	13.95	1841	14.34	1852	15.02	1863	14.96
1831	14.80	1842	13.88	1853	13.79	1864	15.43
1832	14.29	1843	13.81	1854	14.29	1865	14.81
1833	14.21	1844	14.08	1855	14.19	1866	14.94

NOUVEL OBSERVATOIRE.

1867	14.64	1873	14.53	1879	13.50	1885	14.35
1868	14.65	1874	13.72	1880	14.75	1886	14.16
1869	13.81	1875	13.91	1881	14.45	1887	13.09
1870	13.80	1876	14.06	1882	14.35	1888	13.57
1871	13.49	1877	14.64	1883	13.77		
1872	14.82	1878	14.17	1884	14.26		

Mean average for sixty-six years, 14.22°.

The observations show that January is the coldest and July the hottest month; that the greatest variations of temperature between the day and night occur in summer; that from 1867 to 1886 (page —) the coldest day in the average for that period was December 11, *i. e.*, that the average or mean lowest temperature fell on December 11, when the thermometer went slightly below freezing, and the mean hottest day for the same period was July 21.

The highest temperature on record at Marseilles was July 15, 1859, when the thermometer marked 37.7° C. or 99.8° F., and the lowest temperature 11.4° C., or 12.5° F., or 19.5° below freezing point Fahrenheit.

The year 1887-'88 was exceptionally cold. The mean annual, 13.3° C., is one degree below the general mean of the 66 years comprised in the table (page —). To find a mean annual as low as that we must look back 51 years.

As to the rainfall, the table below shows that for the period 1823–1888 the average amount of rainfall at Marseilles was 528 millimetres, or 20.75 inches, a slightly larger quantity than falls at Paris, the average

annual rainfall there being about 520 millimetres. It is well known that the climate of Provence is much drier than that of the department of the Seine. This is explained from the fact that the rainfall at Marseilles is confined to a smaller number of days per year (it rains on the average 78.7 days of each year at Marseilles), and the higher temperature of Provence, aided by the winds, causes a much quicker evaporation.

There is little or no rain May, June, and July, June being the driest month; September is the dampest. The rainfall from year to year varies considerably. Some years, with a larger number of rainy days than the average, give a rainfall (quantity) considerably under the average. Rains are more frequent during the night than in the daytime.

Pluviometrical observations.

Years.	Rainfall.	Number of days of rain.	Number of days of snow.	Years.	Rainfall.	Number of days of rain.	Number of days of snow.
	<i>Mm.*</i>				<i>Mm.</i>		
1823.....	402.30	73	.....	1857.....	694.30	78	.....
1824.....	413.90	57	.....	1858.....	486.73	72	.....
1825.....	432.00	42	.....	1859.....	421.40	76	.....
1826.....	536.30	39	.....	1860.....	472.08	94	3
1827.....	620.50	49	1	1861.....	306.27	60	.....
1828.....	484.30	52	.....	1862.....	783.02	78	.....
1829.....	637.40	84	1	1863.....	654.80	80	.....
1830.....	322.90	63	2	1864.....	668.00	74	1
1831.....	854.50	59	1	1865.....	438.80	82	.....
1832.....	338.90	58	.....	1866.....	453.86	81	.....
1833.....	399.30	70	1	1867.....	371.38	94	6
1834.....	540.48	55	.....	1868.....	741.50	91	6
1835.....	497.05	68	2	1869.....	395.20	73	2
1836.....	722.19	70	2	1870.....	496.25	70	6
1837.....	268.19	66	2	1871.....	531.05	84	3
1838.....	469.85	74	3	1872.....	1,093.15	131	.....
1839.....	906.21	76	1	1873.....	483.95	94	.....
1840.....	538.00	75	1	1874.....	604.22	67	3
1841.....	606.37	69	1	1875.....	438.78	66	3
1842.....	745.05	87	4	1876.....	455.55	93	3
1843.....	679.68	74	1	1877.....	311.80	105	2
1844.....	619.40	97	6	1878.....	467.70	91	4
1845.....	452.37	86	.....	1879.....	727.35	94	3
1846.....	531.69	73	1	1880.....	511.75	88	1
1847.....	401.24	63	1	1881.....	391.95	91	2
1848.....	627.28	85	.....	1882.....	476.70	96	1
1849.....	375.26	66	.....	1883.....	438.80	117	4
1850.....	359.06	66	.....	1884.....	478.15	86	.....
1851.....	502.78	73	2	1885.....	621.60	106	1
1852.....	414.49	78	.....	1886.....	821.60	102	1
1853.....	504.52	102	1	1887.....	651.97	87	5
1854.....	298.52	63	1	1888.....	650.20	107	5
1855.....	489.41	85	1				
1856.....	523.07	86	.....	Mean average.	523.55	78.7	1.56

* Mm. = millimetre = .0393 inches.

There were in all 103 days when snow fell during the 66 years. If we divide this time into periods of 22 years each we see that for the first 22 years there were 290 snows, for the second 12, and for the third period 62. These snows are very light and rarely remain on the ground more than an hour or two after sunrise.

It snowed on the average for the 66 years 1.56 days per year.

By referring to the table for mean annual temperature for the 66 years we see that with the increase in the number of snows in the last 22 years there was a slightly lower thermometer. The general average for the entire period of 66 years was 14.22° C.; for the period 1823 to 1865 it was 14.25° C.; while for the period 1866 to 1888 it was 14.16° C. The years 1887 to 1888 gave 13.23° C. The gradual change going on in the climate of the Midi is attributed to the increased area subjected to irrigation.

The department des Bouches-du-Rhône must not be confounded with "the south of France," to which invalids are sent from the States, England, and the north of Europe, and where the leisure class go to enjoy a perfect climate—one continual spring, amid the loveliest surroundings that nature and art can produce; that "south of France" is several hours by rail from Marseilles, beginning with Hyères, then Cannes, St. Raphael, Nice, Monaco, and so on. The "Rives d'Or" enjoy a milder climate by two or three degrees centigrade than Marseilles. The Mistral does not extend that far, and these resorts are so located that they are protected by the configuration of the coast and the hills from the local winds in winter.

The winds that blow at Marseilles and its vicinity have a direct bearing on the irrigation question. From their frequency and force an explanation is obtained of the dryness of the climate, notwithstanding the number of rains per annum and the quantity of water contributed by the clouds.

Statistics supplied by the city observatory give the number of winds from the eight principal points of the compass for each year from 1874 to 1888, their average annual force computed in metres per second, in kilogrammes per hour, and the wind pressure in kilogrammes per square metre. I regret that I have not the time to give the tables for the 15 years; a general résumé of all the observations must suffice. A study of the table below shows how frequent certain winds are at fixed times of the day, and how seldom it is that there is not some one of the eight winds blowing in this vicinity. Just how far these observations apply to the whole of Provence I am unfortunately unprepared to say.

The observations were taken six times daily from 7 a. m. to 10 p. m., and indicate the number of days on the average each year, for 15 years, there was a wind blowing from the given direction; also the force or swiftness of the winds, they having values generally adopted by meteorologists as follows:

	Character of wind.	Velocity.		Pressure per square metre.
		Per second.	Per hour.	
		Metres.	Kilometres.	
0.....	None.....	0 to 0.5	0 to 1.8	0 to 0.1
1.....	Weak.....	0.5 5	1.8 18	0.1 3
2.....	Moderate....	5 10	18 36	3 12
3.....	Strong.....	10 15	36 54	12 27

Ventose observations; mean of 1874-1888.

Direction of wind.	7 a. m.		10 a. m.		1 p. m.		4 p. m.		7 p. m.		10 p. m.		Average.	
	Days.	Velocity.	Days.	Velocity.	Days.	Velocity.	Days.	Velocity.	Days.	Velocity.	Days.	Velocity.	Days.	Velocity.
North.....	.8	1.1	9.1	1.7	4.8	2.0	6.3	1.8	7.4	1.5	6.7	1.1	5.8	1.6
Northeast...	96.5	.5	21.2	.6	6.5	1.0	5.8	.9	52.3	.5	125.6	.6	51.4	.6
East.....	83.5	1.1	48.8	1.3	25.1	1.9	23.8	1.7	49.6	1.2	61.9	1.2	48.8	1.3
Southeast...	25.6	1.2	40.8	1.8	41.8	2.0	39.4	1.8	39.1	1.5	29.1	1.5	36.0	1.7
South.....	7.1	1.6	16.9	1.4	28.7	1.7	33.1	1.4	15.9	.8	4.9	1.1	17.8	1.4
Southwest...	6.5	.5	32.9	.9	56.8	1.3	58.4	1.2	29.9	.6	8.1	.8	31.8	1.0
West.....	47.3	1.4	90.6	1.3	97.6	1.6	88.5	1.5	67.5	1.0	27.8	1.3	69.9	1.4
Northwest...	93.9	1.8	101.1	2.4	103.7	2.9	108.3	2.9	101.5	2.3	88.3	2.2	101.1	2.4
Days on which there was no w'd at the hour.	4.1	.....	3.9	.....	.2	.....	1.7	.....	4	.....	2.8	.....	2.8	.....

From the six observations of the day the eight winds can be classed according to their frequency, and omitting the fractions, as follows :

Direction of wind.	No. of days.	Mean velocity.
Northwest.....	161	2.4
West.....	70	1.4
Northeast.....	51	.6
East.....	49	1.3
Southeast.....	36	1.7
Southwest.....	33	1.0
South.....	18	1.4
North.....	6	1.6
No wind.....	3	.....
Total.....	366	.....

366 — the omitted fraction = 365 days.

The most frequent wind there is the northwest, or mistral; it is also the strongest, having nearly double the velocity of any one of the other winds. It is this wind that spoils the climate of Marseilles, for when it suddenly appears, one day out of three, the temperature falls at once, and worse still, clouds of gray white dust are driven into the faces and eyes of the unfortunate individuals who happen to be out of doors; indeed, the dust is so fine that it penetrates the houses, throwing its gritty mantle over everything. Lodged in the eye it is painful to a degree, and settled on and driven into dark clothing it is their early destruction. In the summer months when there is little or no rain the trees, flowers, and shrubs around the city become completely covered with the dust, and as the hills are of gray white rock, devoid of vegetation of any kind, and the houses are of gray stone or composition, the aspect of Marseilles and its surroundings, dull at the best of times, is rendered positively mournful. For relief from the monotonous gray spectral hills, gray trees, gray houses, gray everything—the eye turns to the sea. Nothing can surpass in loveliness the intense blue of the Mediterranean.

From the table above it will be seen that none of the winds are violent, that the northwest ones do not approach our western blizzards.

The meteorological table stops at No. 3, because in this locality in velocity and force the winds do not go beyond that figure and its equivalents; while No. 6, in scientific language, means above 30 metres a second, above 108 kilometers per hour, and more than 108 kilogrammes per square metre. But the table is the average of 15 years; exceptional winds, then, must be those that greatly exceed the force there given. The northwest winds at times during the winter have a force sufficient to overturn cabs on the Corniche route, and at certain exposed points on the road the pedestrian has to crawl on all fours to the leeward under the sea wall to save himself from being blown into the sea. Inland, one of the agricultural features of the country is long rows of cypress trees so planted as to protect the crops from these same northwesterners.

The least frequent winds are those from the north, while the weakest are from the northeast.

Irrigation, it is claimed, has greatly modified the force and frequency of the winds.

PART IV.—METHODS OF IRRIGATION AND CULTIVATION.

DESCRIPTION OF SEVERAL PROPERTIES VISITED BY THE FRENCH JURY ON IRRIGATION IN 1875 AND 1876, WITH SOME DETAILS AS TO METHOD OF IRRIGATION AND OF CULTIVATION, THE COST OF LABOR, AND THE PRICE OF PRODUCTS.

The jury appointed by the minister of agriculture to award the government prizes to the contestants showing the best methods of and best results from irrigation, visited more than seventy properties in all. As their report contains a description of each property visited and gives an amount of information too minute and extended for the scope of my report, I can only describe one or two of the places visited in the briefest sort of way. The subject I deem too important to be passed by without at least giving some little notice to it.

From inquiry and observation I learn that the irrigation problem in the Midi has not undergone any sensible change in the past 13 years. The methods adopted are about the same. No material change has taken place in the irrigating canal companies. Their success or failure appears to have been decided at their start to have depended largely on close calculation as to original cost and guaranteed subscriptions.

The cost of water supplied by canal companies has been given in several instances. Just what it costs the farmer depends on the proximity of his land to a canal; whether or not his land is above the level of the canal, on a level with it, or below the level of the same.

The French law permits a farmer to use all the water necessary to irrigate his fields from a river flowing through or by his land free of cost. When the land is lower than the river surface the question of embankment may be the most important for that particular property; when above the level, the cost of pumping the water up to a desired point for immediate distribution or for storage in a reservoir takes a most important place in the items of yearly expenditure for that estate, so that the value of rural property is governed by the ease and cheapness with which water can be obtained, or the contrary. Where nature alone has to be relied on for the rainfall the value of land, as given before, is very low, as the only products under that condition are a coarse and scanty grass and a few trees of little or no value.

Domain of the Mas-de-Fabre, the property of M. Faucon.—The domain of the Mas-de-Fabre, lying in the commune of Graveson, has a total superficies of 36 hectares; 2½ hectares are on the mountain side. When M. Faucon acquired it, in 1855, it was let at an annual rent of 3,000 francs, which was often in arrears, and sometimes not paid at all. In 1858 he undertook the cultivation of it himself, and at once began planting vines, which he continued until 1867. Everything prospered to his entire satisfaction, when, in that year, the phylloxera made its appearance, and his vineyards were completely devastated. How the phylloxera was treated has been already described.

In 1875 the domain was divided as follows:

	Hectares.
Vines cured of the phylloxera by winter submersion and now in full bearing.	16. 00
Plantation of aramons, beginning to bear	5. 00
Plantation of 1874, not yet bearing	2. 00
Plantation of 1875	1. 00
Total for vineyards	<u>24. 00</u>

	Hectares.
Irrigated meadow	3.00
Sainfoin	2.50
Oats	2.00
Irrigated orchard	1.00
Roads, ditches, etc.	1.00
On the mountain side :	
Olives	1.25
Almonds	1.25
Total area of domain	36.00

The place of the Vineyards of the Mas de Fabre is explained as follows:

On the extreme left is the Canal des Alpines, one of the important irrigating canals of the department. Until 1870, M. Faucus made no use of the canal, because his land was slightly higher than the level of the canal. In that year he obtained permission of the canal company to put a bar (barrage) across the canal, and so raised the level of the water as to enable him to carry it in ditches (fossés) over his property.

M. Faucus has, from time to time, planted almost all the varieties of vines grown in the Midi; *en voici la liste* :

Clairette.	Espar.	Mourastel.
Aramon.	Petit-bouschet.	Carignane.
Moustardié.	Brun-fourcot.	Tenet noir.
Œillade.	Cinq-saon.	Tenet-bourret.
Pique-poule.	Gros-Guillaume.	Petit-tenet.
Colambaud.	Pécoul-touar.	Tibourou.
Grand-teoulier.	Sperau noir.	Muscat.
Olivette.	Madeleine.	Joanneuc.
Chasselas.	Grenache.	

Lot A, on the placed adjoining the canal, was planted in 1875 in petit-bouschet. The ground had been leveled and divided in compartments, ready for submersion if required. The blue line represents the ditch by which the water is taken (prise) from the canal and distributed over the vineyards; 1 hectare.

Lot B was planted in 1858 in clairette. Vines nearly destroyed by phylloxera in 1868. Submersion began in 1870 and continued to date. From 1872 to 1875 carefully cultivated and manured. By this process the vines were restored; 2 hectares 75 ares.

Lot C is also planted in clairette since 1859. Treated by submersion, etc., since 1870, which caused restoration of the vines. The ground in this lot is very uneven, hence the many small compartments to secure complete submersion; 3 hectares 80 ares.

Lot D is composed of old vines of 1862 and 1863, a number of varieties; 2 hectares 60 ares.

Lot E was planted in mourivédu in 1864. Both D and E were ravaged by the phylloxera, and treated by submersion since 1870; 2 hectares 90 ares.

Lot F is planted in aramon of different ages. Out of the 25,000 plants in this lot 15,000 were completely destroyed by the insect. Submerged in 1871 and dead plants replaced. In 1875 bearing magnificently.

Lot G was planted in aramon in 1874. Completely submerged for 55 days without injury to the young vines; 2 hectares.

Lot H was planted in grenache in 1861. In 1868 so injured by phylloxera as to be considered lost beyond all question. Treated by submersion in 1870 and since. It is now in such a prosperous condition that the laborers on the estate call it the miracle vine.

Lots I and J are irrigated meadows; 3 hectares.

Lot K, irrigated orchard; 1 hectare.

Lot L, sainfoin; 2 hectares 50 ares.

Lot M, oats; 2 hectares.

Lot N, vegetable garden; 45 ares.

The land given to olives and almonds is not represented on the above plan.

How the vineyards are irrigated, the construction of the ditches, banks, sluice-gates, etc., is fully explained in the diagram accompanying the plan. The measurements are in the metric system.

The composition of the soil of the Mas-de Fabre, reduced to a perfectly dry state, Gay-Lussac retort, 100° C.:

	Per cent.
Clay	38.74
Silicate sand	10.53
Carbonate of lime	43.39
Sulphate of lime .....	.43
Chlorine of sodium .....	.18
Organic matter	6.73
	<hr/>
	100.00
Azote, per cent .....	.12

Another analysis, 100° C. (aqua regalis):

Potash, per cent .....	.0674
Phosphoric acid, per cent .....	.0567

Weak in potash, ordinary in phosphoric acid. It is an argilo-calco-siliceous earth, very rich in lime.

As M. Faucon has but two horses and two mules on the domain, the ordinary farm manure was not sufficient, and commercial fertilizers were used.

One, a mixture composed of 90 per cent of rape-seed oil-cake, which cost 16 francs per 100 kilogrammes delivered, and 10 per cent sulphate of potash, Stassfurt refined, costing 44 francs per 100 kilogrammes delivered. The mixture costs, then, 18.80 francs the 100 kilogrammes.

A second, styled *chemique complet No. 4*, manufactured by Louis Avril, of Marseilles, costing 36 francs the 100 kilogrammes delivered, has the following formula:

	Per cent.
Superphosphate of lime	40
Nitrate of potash	33
Sulphate of lime	27
	<hr/>
	100

M. Faucon treated half of his vineyard with the first of these fertilizers, giving as a dose for each vine 250 grammes, or 1,250 kilogrammes the hectare, an expenditure of 235 francs the hectare. The other half received 125 grammes of the *chemique complet No. 4* per each vine, or 625 kilogrammes the hectare, an expenditure of 225 francs the hectare. The half treated with the oil-cake presented the better appearance.

The irrigated meadow of 3 hectares, sown in an assortment of seed—*fromental*, violet and yellow clover, lucern, and several other varieties, was treated at the time the seed was sown to 3,000 kilogrammes of chemical fertilizer *No. 1*, composed:

	Per cent.
Superphosphate of lime	34
Nitrate of potash	17
Sulphate of ammonia	20
Sulphate of lime	29
	<hr/>
	100

This fertilizer costs 33 francs the 100 kilogrammes, freight included. This meadow, sown September 1, received its first mowing the 24th of May following, and yielded 7,000 kilogrammes to the hectare. The second mowing occurred in July, yielding 1,666 kilogrammes to the hectare; the third in August, yielding 2,000 kilogrammes to the hectare; the fourth in October, yielding 800 kilogrammes to the hectare. The total product for the first year, then, was 11,466 kilogrammes to the hectare. M. Faucou considered this result quite satisfactory, and calculated on a much larger return the next year, as the plants ought then to have greater strength.

The meadow was irrigated twice between each mowing. The annual cost of the water was 35 francs the hectare. The grass was cut with scythes at 15 francs the hectare. The haymaking is done by two women, in three or four days, at 1.25 francs each. The hay is then carried into haylofts by men, paid from 2.50 francs to 3 francs each a day, each man storing away from 1,200 to 1,500 kilogrammes of hay in a day. The lofts are at the side of the meadow. No horses or wagons are employed in this labor. Finally, the hay is sold at 10 francs the 100 kilogrammes.

To return to the vines. The wine production at the mas du Fabre for 9 years gives us:

Year.	Time and character of treatment.	Quantity.
		<i>Hectolitres.</i>
1867.....	Year preceding the invasion of the phylloxera; vines manured but not submerged.	925
1868.....	First year of the pest; vines manured, but not submerged	40
1869.....	Second year of the pest; vines manured, but not submerged.	35
1870.....	First year of submersion, without fertilizing.	120
1871.....	Second year of submersion, without fertilizing.	450
1872.....	Third year of submersion, with fertilizing.	849
1873.....	Fourth year of submersion, with fertilizing.	786
1874.....	Fifth year of submersion, with fertilizing.	1,175
1875.....	Sixth year of submersion, with fertilizing.	2,480

The quality of the wine is "bon ordinaire," and it sells for from 31 to 40 francs the hectolitre at the vineyard.

The use of the American vine to replant the vineyards destroyed by the phylloxera is not germane to this report, the object being to show what irrigation has accomplished in the medi of France, and how it was done.

Domain of La Darcussia, the property of M. Jules Imer, in the commune of Marseilles.—The domain of La Darcussia, 19 hectares (81 acres) in extent, consisting of irrigated meadows, and situated on a hillside in the commune of Marseilles, was purchased in 1850. At that time the hill was arid waste land. As the Marseilles canal did not pass near enough to the property to make use of its waters directly, M. Imer constructed a branch canal, which cost him 7,500 francs, thus bringing the water to his estate. Adjoining property-owners afterwards purchased interests in this branch, and so reduced the original expense of M. Imer two-thirds.

The branch canal is tapped (prise) at four points to irrigate the estate. These prise measure 30 centimetres in width and 60 in depth, and are so planned that an abonnement or subscription for one litre means 43 irrigations of 3 hours' duration, with a flow of 34 litres per second during each period of 3 hours. The table below represents the arrangement in 1875, the subscriber receiving the quantity of water due him from the 4 prises in succession at intervals of 17 days during 183 days of the summer season:

Number of tappings (prise d'eau.)	Quantity taken.	Duration of navigation.	Total quantity for the irrigat- ing season.
	<i>Litres.</i>	<i>Hours.</i>	
1	3.0	9.0	47,368,800
2	4.0	12.0	63,158,400
3	4.5	13.5	71,033,200
4	1.5	4.5	23,684,400
	13.0	39.0	205,244,800

The four prise d'eau, then, supply 13 litres. A fourteenth litre is used for the ram (belier). The water falls 10 metres, and the ram pumps it up 18 metres to a basin or small reservoir, where it is stored to be used as occasion requires. The canal company permits M. Imer to take this water when the canal is very full, i. e., when there is more water in the canal than is required for the irrigation.

In addition to the above, 3 modules (three-tenths of a litre per second), to be used all the year, are employed in the domain for the house and garden. This water is conveyed to the estate in an underground pipe, and costs 250 francs a year.

One man is employed to irrigate the fields. He receives 25 centimes (5 cents) an hour during the daytime and 50 centimes (10 cents) during the night. He works at this the whole year. A cartman, at 100 francs a month, is employed, principally in carting manure to different points in the domain, spreading it, etc.

There are 3 horses and 1 cow on the estate. These supply part of the manure; the remainder is brought from the city. Total expenditure for manure, putting it at 3½ francs the cubic metre, is 2,150 francs per annum. For mixing and spreading it 375 francs more. The canal company is paid 1,400 francs a year. The city of Marseilles imposes an octroi tax of 1,296 francs on the hay grown within the city limits. The growing hay crops (12 hectares) then costs 5,470 francs. Include in the above an item of 249 francs paid the irrigating man.

The hay is cut four times a year, and the expense of cutting, curing, and putting it under cover amounts to 1,050 francs for the four crops. M. Imer uses a Wood mowing machine and a Howard hay-maker, also a horse rake. M. Imer was one of the first agriculturists in this vicinity to make use of machinery in grass culture, and is regarded as a very progressive man, indeed.

The total average hay product is 110,000 kilogrammes, or 9,000 kilogrammes to the hectare for the four cuttings. Hay sold at that time for from 12 and 14 to 18 francs the 100 kilogrammes. At 12 francs the year's crops, then, would bring 13,200 francs.

The entire expenditure, not including value of land, was 6,520 francs. Sale of product 13,200 francs, or net proceeds 6,680 francs, or 556 francs per hectare, or \$45 per acre.

The cost of putting in pipes, making ditches for irrigation, etc., is not included, and I am unable to obtain the figures.

The grass is the common meadow grass, and was not sown.

Domain of Lamotte, in the commune of Tarascon.—The domain of Lamotte, at one time the rendezvous de chasse of King René, is situated 4 kilometres from Tarascon, and is bounded on one side by the departmental road No. 15, between Arles and Avignon. It contains 132½ hectares, divided up as follows:

	Hectares.
Chateau and gardens.....	4
Reserve.....	10
The Menage farm.....	28
The Convent farm.....	28½
Marsh.....	3
Mountain reserve, woods.....	61
	<hr/> 132½

Two parts of the estate are farmed on shares, the Menage and Convent farms. The agreement is for 9 years. The farmer or *métayer* can leave at the end of the third or sixth year by giving a year's notice in legal form. The agreement is for an equal division of the crops, under the following conditions:

First. The farmer must live on the farm with his family, and have not less than three horses or mules and not less than eighty sheep. He is not to farm any other land. He is to cultivate, sow, and harvest at the proper seasons under the direction of the landlord or his overseer. The farm is to be cultivated according to the rules of good husbandry under penalty of damages and interest to the landlord.

Second. Wheat, oats, and barley seed for sowing the farmer is to supply at his own expense. Seed of lucern and meadow grass is supplied half by the farmer, half by the landlord. The farmer is to haul the landlord's share of the crops to any place indicated, not exceeding 6 kilometers, without compensation.

Third. The farmer or tenant during his tenancy must make at least 4 hectares of lucern, prepare the ground, level it, and make it easy to irrigate.

Fourth. Every third year the tenant must set in vines 1 hectare, leveling the ground so that submersion of the roots can be properly accomplished. The proprietor, or landlord, supplies the plants. Should the vines bear during the first 3 years the tenant is to have the grapes; after that time he makes the vintage and the wine is equally divided.

Fifth. The tenant must make all the manure he can with his horses and sheep, and put it on the farm; if it is necessary to use commercial fertilizers, the tenant bears one-third of the cost.

Sixth. Once during his lease the tenant must pay half the expense for rebanking the canal; he must keep in good condition the drains and ditches.

Seventh. The tenant must cut down all the dead trees; the small branches are for him, but the trunk and large branches are the landlord's.

The tenant is to enjoy certain benefits: a garden of 17½ ares; a lot, 35 ares, for his sheep; a poultry yard; he can sow 70 ares of stubble in oats for his flock to pasture on; the sixth cutting of lucern and the fourth of meadow are also for his flock; he is to have the trimmings from the olive and mulberry trees, any large branches, however, must be divided with the landlord; and from November to February he can turn his flock into the woodland belonging to the domain.

The landlord pays for the making of the main ditches, but the tenant must keep them in order. In case it should be necessary, owing to a flood, to re-seed a field sown in cereals the landlord pays for one-half the seed.

The tenant is to perform certain work for pay on the domain of which the farm leased to him forms a part, and on the account current kept by him and the landlord any money due him from the landlord is applied to the payment of his share of fertilizers.

The landlord is to have, under his "titre de souquets," 300 francs, payable in money or wheat; also, 6 pairs of chickens, 3 ducks, 12 dozen eggs, and for the use of the chateau, whenever he is living on the domain, such fruits, vegetables, and milk as may be necessary. Half the honey is, also, his.

These items are taken from a copy of the lease. The tenant farmer can not complain that his work and compensation are not sufficiently indicated as to details in this agreement.

There is an overseer on the domain, charged with the general supervision of the estate, selling the crops, buying the fertilizers, etc. He works the year round on the domain, the two farms excepted; has a garden of 8 ares 75 centares for his vegetables, and a pig. His pay is 700 francs per annum, or about \$140. His especial care is to cultivate the reserve of 10 hectares, 7 hectares of which, set in lucern and meadow grass, are represented in the accompanying plan.

The water, which comes from a branch of the Canal des Alpines, and not from the Roubine de Lamotte, is let into the reserve at the "Martellière de prise;" after which it is conducted by the "filiole principale" through the center of the reserve, and "filiolles secondaires d'arrosage" conduct it at equal distances over the reserve. The "filiolles" are irrigating ditches, and the field is so prepared that the ground slopes slightly from the "filiolles" in both directions. When the water is let in there, it flows through the filiolles irrigating the land on both sides, and the excess of water is drained off into the "fossés d'écoulement" or drainage ditches. These ditches empty into a "fossé de colature," which carries off the excess of irrigation from the entire field, the "fossés d'écoulement" passing under the farm road or "chemin d'exploitation," and emptying into the "fossé de colature" on the opposite side of the road. The "filiole" takes the water from the branch Canal des Alpines, and by means of a siphon carries it under the public road, and so conducts it into the estate where it is distributed over the fields by smaller filiolles.

The longitudinal section on the plan marked "Luzerne 1873" is 140 metres in length, *i. e.*, from the filiole principale to the fosse de colature, and 43 metres in width, *i. e.*, from the filiole secondaire to the chemin d'exploitation.

From this field of 7 hectares (the plan), 5½ hectares of which are in lucerne, 5 lucerne crops are made a year. A smaller growth, called the sixth crop, is pastured to the sheep.

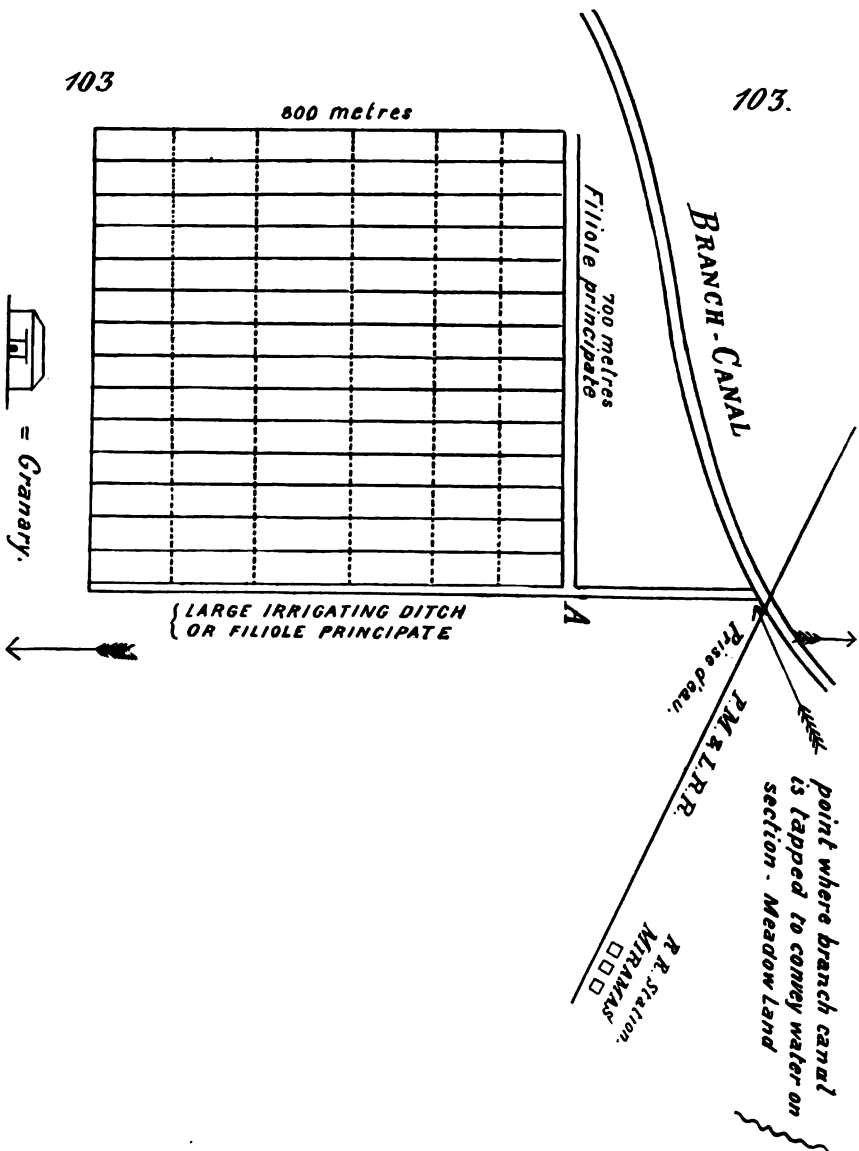
The 5½ hectares yielded :

	Kilogrammes.
First cutting	1, 650
Second cutting	2, 200
Third cutting	3, 300
Fourth cutting	2, 750
Fifth cutting	1, 650
Sixth cutting (estimate of) pastured to sheep.....	450

For the year 12, 000

The crop sold for from 7 to 10 francs the 100 kilogrammes, or from 840 to 1,200 francs the hectare.

The mowing costs 7 francs the hectare, and is done by men at 5 francs a day, from 4 a. m. to 7 p. m. Haymaking is done by women at 1 franc 25 centimes (25 cents) a day. The field is irrigated four times for each mowing or cutting. This the overseer does, each irrigation taking only 2 or 3 days. All he has to do for this is to regulate the sluices, the ground being so leveled off that the excess of water runs off easily.



The lucerne is manured every year, one year farm manure and the following some chemical fertilizer. The farm manure is applied 35 to 40 cubic metres the hectare, the fertilizer from 300 to 600 kilogrammes.

Deducting expense of irrigation, manure and fertilizers, and harvesting, the lucerne crops gave 600 francs profit per hectare.

The cost of preparing the ground for irrigation and seeding in lucerne, 1 hectare, was 548 francs, plus 320 francs for manure, or 768 francs in all. The seed cost about 25 francs per hectare.

Lucerne once well set will last 5 years, giving the best returns about the second year.

Among the items given by the proprietor of this domain, not mentioned heretofore, is the price of the sluices for irrigation, stone work, and sheet-iron slide, 40 francs each.

The $1\frac{1}{2}$ hectares of meadow pré on the plan, make about the same return as the lucerne.

The vineyards on the estate are cultivated after M. Faucon's method.

Domain of Sulauze, the property of M. Paul, of Marseilles.—In order to obtain as satisfactory information as possible concerning irrigation in this department I visited M. Paul's property at Miramas, about 30 miles from Marseilles, in the Crau. It was December 10, and the irrigating season being over the canal and ditch were dry; but as this enabled me to see the construction I considered that no disadvantage.

I had only time to examine the meadow, irrigation of meadow land being regarded here as the most important.

It is 56 hectares in extent, and as the land here is a dead level without a single tree, the problem consisted in preparing the ground and making the ditches.

The ground in its natural state produces absolutely nothing. A section adjoining the one on the plan on which work had not yet been commenced, and the country for miles round in its natural state is the same, was completely covered with stones, mostly round, and from 3 to 9 inches in diameter. No soil could be seen. A few inches below these stones there is a light sandy soil full of pebbles; still lower, at a depth of 1 to 2 feet is a layer of pudding stone, and below that loose pebbles again.

Work was commenced on the section in the plan by removing the larger stones. Deep furrows were run in the ground till the pudding stone was reached, and as many stones as possible were buried in this way. Others were driven down into the ground with heavy mallets. Even after this work the appearance of the land was that of a dry river bed, there being as many stones as ever only somewhat smaller.

To irrigate the section the branch canal (*vide*, the plan) was tapped at the point "prise." The branch canal has a depth of about 4 feet and measures at the top from side to side about 6 feet. A large ditch somewhat over half the size of the branch canal conducts the water to the point A where it divides, there being a double sluice made of masonry with sheet iron slide to regulate the flow, and then the filioles principales carry it along two sides of the section. The red lines indicate thirteen smaller irrigating ditches about half the size of the filioles principales. Along the sides of all the ditches are short pieces, 1 to 2 feet in length and 6 to 8 inches through, of clay pipe (tuyau) to run the water from the ditches over the ground. The dotted lines indicate small earth ridges 6 to 8 inches high. The clay pipes have clay stoppers, so that as the section is arranged in the longitudinal planches with the bourselets, or ridges, and the pipes about 30 feet apart, each small

section on the plan can be irrigated in turn. The ground having been seeded in grass the water is turned on, and 75 litres a second are used to irrigate the section. The section is watered once a week during the season. In other words the men employed night and day in watering the section must get round the fourteen planches in the week.

The water thus spread over the ground comes from the Durance and is heavily charged with mud. It is this mud deposited by the water that forms with the sand a soil strong enough to produce remunerative crops of hay.

The cost of labor in preparing this land—i. e., the first outlay—was from 500 to 600 francs the hectare.

The annual expense per hectare is:

	France.
Water, 1½ litre	60
Fertilizer	90
Mowing hay	12
Curing same	20
Putting same in granary	15
Wages to man for watering each hectare during season	6
	<hr/> 203

Cost of putting down 1 hectare in meadow, say 500 francs.

	France.
Yield per annum of hay on this section, per hectare, 6,000 to 8,000 kilos, or say 7,000 at 6 francs the kilo	420
Annual expense, as above	203
	<hr/> 217
Annual returns	217

In 1875 and 1876, it will be remembered, hay brought 12, 16, and even 18 francs the kilo. Six francs the kilo is about \$12 per ton.

The section above described, without irrigation, would produce absolutely nothing. This part of the domain prior to the work expended on it had no value at all, the property having been purchased for the fine chateau, and as a game preserve.

A section of meadow 10 years old, adjoining the one above described, presented a magnificent appearance. The stony ground had been covered 3 to 4 inches deep with the canal mud, and the yield from this per hectare, was 10,000 kilogrammes the season. The hay is cut five times during the season; what is called the sixth crop being pastured to the sheep in the autumn.

For a day's labor a man is paid 50 cents, women 25 cents.

The machines used on the domain are English make—a Howard mower and a Wood rake.

A small railroad (Chemin de fer Decauville) forms a part of the farm machinery. This is very light in construction, and is moved from one section to another as the hay is cured, women carrying the hay in baskets and putting it in the small cars. One horse then pulls the miniature train to the granary.

This building, of stone and mortar, is about 150 feet long, 60 high, and 60 from side to side. A part of one side is open, there being no windows in it. The cost of same was \$12,000.

The only American implement on the domain was one four-pronged stable fork.

Some indication of the climate may be given from the fact that there was one-half inch of ice on the ponds, and still water, which did not melt

during the day, the sun being partially obscured. There was no wind blowing, but the force of the mistral could be inferred from observing how the roof of the granary—a tile roof, very well made, and firmly secured to the wall—had to be weighted down with large boulders to prevent its being carried away by the wind.

PART N.—CONCLUSION.

REPLIES TO THE IRRIGATION QUESTIONS OBTAINED THROUGH THE ENGINEER-IN-CHIEF OF THE DEPARTMENT.

In response to a request for information upon irrigation, the engineer-in-chief of the department has had the kindness to supply me with the following answers to the questions obtained from his subordinates in certain arrondissements and cantons. A circular note was sent with the questions:

- (1) Areas of land under irrigation; compare with the nonirrigable and cultivable areas when possible. Also, quantity and quality of crops grown.
- (2) Sources of water supply, whether from rivers, streams, springs, lakes, wells, reservoirs, catchment basins, or tanks, etc.
- (3) Character of works used for storage and distribution of water.
- (4) The system of water distribution, whether governed by laws, rules, and regulations, or custom. Give duty of water per hectare, *i. e.*, the amount used per hectare and per season; the cost or rental to user; tenure of ownership of water, and whether the same be public or private, national or community?
- (5) Character of climate in irrigated region and nature of soil; annual rainfall or other precipitation.
- (6) Antiquity or otherwise of irrigation systems within the section treated of, and whether the same are maintained at public or private expense.

To which questions the agent, Voyer, for the Canton des Martigues has replied as follows:

	Hectares.
(1) Commune des Martigues, irrigated (about).....	40
Commune de Chateauneuf, irrigated (about)	50
Not irrigated.....	1,000

Crops consist of wheat, primeurs, fruits, olives, and dried vegetables. Very little wine.

(2) In the commune des Martigues, Port-de-Bouc, and Gignac from the Durance; in those of Marignane and St. Victoret from la Cadière (stream); in those of Chateau neuf Carry, and le Rove from springs and wells.

(3) In the communes des Martigues, Port-de-Bouc, and Gignac the water is brought in canals and distributed in the town by means of fountains. There are some wells. In those of Marignane and St. Victoret, where the stream la Cadière supplies the irrigation, only water for domestic use is obtained from cisterns and wells. In those of the Rove, Carry, and Chateauneuf, for the most part, there is an abundant quantity of spring water. For domestic use there are wells.

(4) In the commune des Martigues the distribution of water is governed by a law and prefectoral decree of July 9, 1884. The concessions for water are for at least fifteen years. Water for the irrigating season is sold at 30 francs the litre. For continual use and for houses there is a special rate.

The irrigating canal is the property of the commune.

The commune of Port-de-Bouc has a canal, taken from the Martigues Canal, for which it pays 610 francs a year for a litre a second.

In the communes of Martigues and of St. Victoret the use of the water is managed by a syndicate.

In the commune of Chateauneuf the irrigation is not governed by any law or regulation, the water belonging exclusively to the proprietors.

(5) The nature of the climate and of the soil is warm. The soil is limestone.

The average rainfall at the observatory of Port-de-Bouc is as follows :

Year.	Average rainfall.	Year.	Average rainfall.
	mm.		mm.
1882.....	641	1886.....	509
1883.....	452	1887.....	676
1884.....	483	1888.....	393
1885.....	506		

(6) In certain communes the expense falls on the communes; in others, in general, on the proprietors.

The construction of the irrigating canal of Martigues and its management date from 1880.

MARSEILLES.

(1) The city of Marseilles is so divided up that it is difficult to give the exact amount of land irrigated. The Marseilles Canal irrigates about 3,500 hectares with 4,600 litres per second.

The crops are hay, wine, wheat, and olives.

(2) The irrigating water is obtained from rivers, streams, springs, and wells. The rivers are the Durance and the Huveaune; the streams are the Jarret and les Aygallades.

(3) The water from the Durance is brought to Marseilles by a canal. Its distribution is accomplished by tapping the said canal at different points.

That from the Huveaune is brought in a canal, and is also used for motive power. This branch goes by the name of the Canal of St. Marcel and St. Guinez. It is constructed of stone (masonry) and earth.

(4) The water from the Durance, as well as that from the Huveaune, is governed by regulations as to its distribution; that of the streams by usage.

The water concessions for the city of Marseilles are for fifty years. The cost per annum is 80 francs a litre per second. The Marseilles Canal belongs to the commune of Marseilles. The Huveaune branch belongs to private parties. The water that passes into the streams de Jarret and des Aygallades belongs to the riparian owners.

(5) The nature of the climate is generally warm. The mean temperature from 1886 to 1887 was 14.20°. The rainfall (mean) from 1866 to 1887 was 526.68 millimetres.

(6) The construction of the Marseilles Canal dates from 1839 to 1847. The cost of maintenance is borne by the city of Marseilles. The construction of the canal of St. Marcel dates back to 1417. The expense of maintenance falls on the riparian proprietors.

THE CANTON OF ISTRES.

(1) The number of hectares irrigated is about 3,000. There are about 3,100 hectares cultivated, but not irrigated.

The crops are hay, wheat, olives, almonds, and wine. Hay, wheat, and olives take up about three-fourths of the cultivated land. The total value of the crops is about 650,000 francs.

(2) There are two canals, les Alpines and les Craponnes.

(3) The water is taken from the river Durance by means of floating bars (ouvrages mobiles), dikes, or other works, and is conducted by the canals already named. It is divided and distributed by secondary canals, sluices being used to regulate the flow. The only plans I know of are those of the branch canal of St. Mitre, to be obtained from the commune of St. Mitre.

(4) The distribution of the water is governed by particular regulations, which vary. The amount used per hectare during the summer season is 24 litres. The concessions for water are perpetual. For the canal de Craponne they are gratis, and for les Alpines at a certain sum. The annual expense is very changeable, and goes from 15 to 45 francs per hectare. The canals belong to private parties or to associations.

(5) The soil of the canton of Istres is stony and rocky. The climate is temperate.

(6) The canal de Craponne was constructed in 1560; that of les Alpines in 1870. The expense of maintenance is borne by those who use them.

ARRONDISSEMENT D'ARLES.

(1) In the communes of Mourîès and les Baux there is no land under irrigation; in the commune of Maussane, of 3,168 hectares, only 10 hectares are irrigated, meadow and garden; in the commune of Paradow, of 1,615 hectares, 10 hectares irrigated, meadow and garden; in the commune of Fontvieille, 3,962 hectares, 180 hectares vineyards, are irrigated.

(2) Springs and streams.

(3) The streams are tapped by the riparian proprietors and the water is distributed by means of ditches.

(4) The distribution is governed by custom; the quantity used varies according to the dryness of the season, from 2 to 3 litres the hectare.

(5) The climate is dry and the soil calcareous.

No record of the rainfall is kept except in the commune of les Baux, where the average monthly quantity is 52 millimetres.

(6) The expense of irrigation is borne by private parties.

TARASCON.

(1) In the canton of Tarascon only a part of the commune of Mas Blanc and of the plain of Tarascon is irrigated. The principal crops are wine, hay, cereals, fruits, and piments. The vine is treated by submersion in the plain; on the banks of the Rhône the sand protects it from the pest (phylloxera). The American plants are largely used to replace the destroyed vineyards.

(2) Water is supplied by two canals from the Durance. The water from these canals is used for submerging the vines, but in five large domains at Tarascon water is taken from drainage canals by means of hydraulic pumps. Some gardens are watered by wells, but the surface so irrigated is very small.

(3) Each of the two canals derived from the Durance has its distinct prise (tap). The water for irrigation and submersion is distributed by means of irrigating ditches.

(4) The distribution of water is governed by rules which the canal guards are instructed to see are observed. For the duty of water per hectare apply to the office of the canal at St. Remy.

For submerging vines the duty is 50 francs per hectare the season, and the concession is for ten years.

The irrigating canals are the property of the Compagnie Française d'Irrigation. The drainage canals are the property of the commune. Proprietors do not pay any indemnity for using these waters.

(5) The climate is warm; the nights are generally damp. The soil in the plains is composed of alluvia of the Rhône and the Durance. It is generally sandy and at some points quite rich. In that part which may be considered as the continuation of the slope of the Alps and of la Montagnette the soil is lighter and for the most part gravelly.

(6) Apply to the canal des Alpines.

CANTON OF AUBAGNE.

(1)

Commune.	Total area.	Area of arable land not irrigated.	Area of land irrigated.
	Hectares.	Hectares.	Hectares.
Aubagne.....	5,518.63	2,259.03	677.33
Gomenos.....	3,193.78	502.36	208.46
La Penne.....	356.12	93.07	83.45
Cujes.....	3,881.17	766.59	.....

In the four communes the crops consist of cereals, forage, and divers vegetables.

(2)

Commune.	Source of irrigation.	Area irrigated.
		<i>Hectares.</i>
Aubagne	Durance (branch of the Canal de Marseille).....	443
	Huveaune	234.33
Gemenos	Durance	111.50
	Spring (St. Pons)	96.96
La Penne	Durance	53.50
	Natural springs (Mâtré)	24.10
	Huveaune	6.85
Cujes	No part of the commune irrigated	

(3) The water of the Durance is conveyed to Aubagne by a canal, for the most part of masonry, and is a branch of the Canal de Marseilles. It is distributed by the cantonniers (roadmen), who tap the main branch and supply the water to the different proprietors by means of pipes of masonry. The water of the Huveaune is taken from the river at Pont de l'Etoile and conveyed through an earthen canal to Gast, Beaudin, and Camp-Major. Pipes convey the water from the canal to the different lands irrigated.

Gemenos: The water of the Durance is conveyed and distributed as in the commune of Aubagne. As regards the spring St. Pons, the water is brought to Gemenos by a simple conduit, partly earthen, part masonry, and conveyed to the different districts by pipes.

La Penne: The water of the Durance is conveyed and distributed as at Aubagne. The water of the Mâtré comes from natural springs and is collected in an earthen canal. The lands traversed by the canal are irrigated in turn, that is, when there is water in that part of the canal which passes through the estate. The Huveaune supplies water to the communes of Aubagne and La Penne, which is distributed by a canal passing through the different estates.

The plans for the construction of the canal of the Durance are kept at the mairie of Marseilles (the bureau du canal). Of the other canals of irrigation in the commune of Aubagne there exist no plans.

As regards the canal of the Durance, which supplies the communes of Aubagne, Gemenos, and La Penne, there are certain regulations. Every concessionaire (grantee) has a right to 34 litres per second during a period of three hours in every one hundred and two hours. From April 1 to September 30 the distribution continues day and night.

The quantity of water supplied in the season per hectare is 15,811,200 litres. The concession is for 50 years. The cost is 80 francs, yearly, per litre, besides 400 francs for initial expense of laying on and 15 francs per tap. The canal is the property of the town of Marseilles.

The waters of the Huveaune are divided between three syndicates, Gast, Béandnard, and Camp-Major. The distribution is regulated. Every proprietor takes his turn; the one begins when the other has terminated. He has a right to all the water passing through the pipes for a certain period, which varies according to the extent of the land to be irrigated; in general, every eight days. The quantity supplied per hectare is variable, depending on the amount supplied by the river. The concessions are perpetual. The proprietors pay an annual rent of 60 francs per hectare at Gast and Beaudinard, and 40 francs at Camp-Major. The construction of the taps is at the charge of the syndicates, who are the proprietors of the canals of irrigation. The distribution continues from April 1 to September 30, day and night.

The river Huveaune being sometimes dry, the syndicates of Gast and Beaudinard have a concession from the Canal de Marseille, the former of 40 litres, the latter of 30 litres, affording the necessary water in case of need.

The water from the spring of St. Pons is distributed by the cantonniers (roadmen) of the syndicate of Gemenos. The proprietors are supplied with water in their turn. They have a right to all the water passing through the pipes during a period, varying according to the extent of land to be irrigated. The turn comes round generally every ten days. The quantity of water is variable. The concessions are perpetual. The proprietors pay a rent of 32 francs per hectare. The syndicate is the proprietor of the canal and constructs the taps. The distribution continues from April 1 to September 3, day and night.

The water of the Maïre, which irrigates part of La Penne, is not regulated by any laws. The proprietors have a right to the water which passes through their estate in their turn. The volume varies with the supply from the spring. The proprietors have a vested right and pay no rent.

The water of the Huveaune, which supplies a small part of La Penne, is not under any regulations. The proprietors have a right to the water once a week for 24 hours. As there are only two of them, each supplies himself for 12 consecutive hours. The quantity varies. They pay no rent.

(5) The climate of Aubagne is mild; about 14 degrees on the average; the soil is clay-limestone. Average rainfall from 1862 to 1887 about 565 millimetres.

(6) The works connected with the canal to convey the water of the Durance, date from 1868; irrigation began in 1870. The expense of maintenance falls on the town of Marseilles.

The other irrigation works of the canton date from time immemorial. The expense of maintenance falls upon the syndicate. As regard the Maïre and the Huveaune, which only irrigate a part of La Penne, the expense falls upon the proprietors of the land watered by them.

ST. RÉMY.

(1)

Commune.	Total area.	Arable land, irrigated or not.	Land irrigated.
	<i>Hectares.</i>	<i>Hectares.</i>	<i>Hectares.</i>
St. Rémy	8,750	5,164	685
Eyragues	2,015	1,700	210
Graveson	2,292	1,982	140
Masblanc	148	121	25

Crops consist of forage, vines, corn stuffs, primeurs, vegetables, and oats.

(2) The Durance supplies water for irrigation. In the communes of St. Rémy and Eyragues an important district is irrigated by means of a canal called the "Réal." The two water courses have their source in the Molléges and St. Andiol. The lands watered by these two canals and the vineyards subject to submersion are not included in the tabulated figures given above.

(3) The water for irrigation purposes is brought by the north branch of the Canal of the Alpines. It is distributed by means of main conduits which supply secondary pipes. About a kilometre to the east of St. Rémy the canal is divided into two branches, one of which supplies St. Rémy and Masblanc; the other Eyragues and Graveson.

There are no plans of the works in the offices of the canal at St. Rémy, but simply a general map of the lands irrigated.

(4) The distribution of the water is according to a regulation dated January 18, 1867. The quantity of water supplied is 1.07 litres per hectare from April 1 to October 1. The concessions to private individuals are sublet, hence a variation in the areas irrigated every year. The charge varies according to the market price of wheat, at the rate of 1.49 litres per are. The canal is the property of the French company of irrigation of the Canal of the Alpines.

The Réal of St. Rémy is the property of Mr. Mistral Bernard and all the subproprietors have a free right to the water. In consequence there are no statistics as to the extent of area irrigated by this canal. The same is the case with the Réal of Eyragues, which belongs to the commune.

(5) The temperature is mild as long as the north wind does not prevail. The soil is, on the whole, gravelly.

In the territory of Maillanne, parts of the southwest of Graveson, and the northwest of Eyragues the soil is of a rich vegetable character. The average annual rainfall at St. Rémy for the years 1882 to 1885, inclusive was 593 millimetres.

(6) The construction of the works connected with the Canals of the Alpines (branches of Eyragues and St. Rémy) dates from 1856, and the expense of maintenance is borne by the company which has the concession.

The maintenance of the Réal of St. Rémy is at the expense of Mr. Bernard, proprietor. The expense of the maintenance of the Réal of Eyragues is borne partly by the commune and partly by the millowners of this part of the water course.

(1)

Commune.	Total area.	Area cultivable.	Area irrigated.
	<i>Hectares.</i>	<i>Hectares.</i>	<i>Hectares.</i>
Barbentanne.....	2,990	1,650	125
Chateaufrenard.....	3,060	2,850	2,450
Noves.....	2,637	2,090	405
Rognonas.....	908	720	200

The chief crops consist of cereals, vines, olives, vegetables, oats, barley, peaches, apricots, and lucerne.

(2) The Durance supplies water to the different branches of the Canal of the Alpines and those of Chateaufrenard and St. Andiol. Chateaufrenard is partly supplied by the Anguillon and the Réal, which are natural streams.

(3) The water is derived from canals which are kept in reserve by means of sluices, and distributed by small trenches called "filioles." The two branches of the Canal of the Alpines which irrigate Barbentanne and Rognonas have a tap in common on the Durance, at Puech, near Noves. The tap of the canal of Chateaufrenard is about 300 yards higher up the river.

The Canal of St. Andiol is a branch of the Canal of Brigelin, which is supplied by the Durance near Mallemost. A secondary branch of the Canal of the Alpines, which irrigates Noves, is supplied by the main branch, which also has a tap at Mallemost.

There are no plans existing of the works connected with these canals. There is simply a general map of the lands irrigated, which can be procured at the company's office at St. Rémy. The syndicate of the Canal of Chateaufrenard have a general plan of the lands irrigated and of the works constructed in 1887, which can be procured at the office of the syndicate at Arles from the engineer.

(4) Canal of Chateaufrenard: The distribution of water is regulated by "gardes" in accordance with a prefectural regulation dated September 25, 1853. The quantity of water per hectare is not limited. The syndicate of Chateaufrenard is empowered to take 3 cubic inches per second from the Durance; and from the Réal, only once a week. It has right to all the water of the Anguillon extending from the wooden bridge to the Durance. The concession is annual.

The annual payments for irrigation are as follows: First class, 16 francs per hectare; second class, 11 francs per hectare; third class, 6 francs per hectare. The canal of Chateaufrenard belongs to a syndicate. The Anguillon belongs to the syndicate formed for draining the marshes of the Anguillon as far as the wooden bridge; from the wooden bridge to the Durance it is the property of the Chateaufrenard syndicate. The bed of the Réal belongs to Mme. la Marquise de Valory; the water to the millowners.

Canal des Alpines: The distribution of water is regulated by "gardes" according to a prefectural regulation of January 18, 1865. The quantity of water supplied is 1.07 litres per hectare during the period of irrigation; that is, from April 1 to October 1. The tax is 35 francs per hectare, and the engagement must be for a minimum period of 3 years. The main and secondary branches belong to the Cie. Française d'Irrigation and the ditches and trenches to the irrigators.

(5) Branch of the canal (St. Andiol): The distribution is regulated by a "garde" (keeper). The quantity of water per hectare is not and can not be limited, the volume being very variable. The concessions are perpetual. The annual charge is 7 francs per hectare. The canal and trenches belong to a syndicate of irrigators.

The climate is rather dry and generally mild when the mistral is not prevalent. The soil is gravelly, but with the exception of some districts is very fertile and well adapted for the culture of primeurs. Some districts of Chateaufrenard are also very fertile, the soil being sandy. A strong vegetable soil prevails in the commune of Noves.

There is no water gauge in the communes of Barbentanne, Chateaufrenard, and Noves, but the average rainfall is about 500 millimetres.

(6) The canal of Chateaufrenard was constructed from 1789 to 1795, according to a design of 1783, and is maintained by the syndicate. The Anguillon and the Réal have existed from time immemorial, and the expense is borne part by the syndicate of the Chateaufrenard and part by the "Syndicat des Marais;" the Réal, part by the syndicate of the Chateaufrenard and part by the commune of Eyragues.

The two branches of the "Canal des Alpines" were constructed in 1868. That of Noves in 1855. The expense is borne by the "Cie. Française d'Irrigation." The irrigators maintain in order the small ditches.

The "Association Syndicate" of the commune of Noves was formed in 1834, and bought at that date from M. d'Estourmel the branch of the Canal St. Andiol. The expense of maintenance is borne by the syndicate.

LA CIOTAT.

(1) It is scarcely possible to state the exact area of land irrigated, because the greater part of the 30 litres of water conceded to La Ciotat by the city of Marseilles serve to supply the wants of the population. However, a few gardens and tracts of land are slightly irrigated.

The chief products are oil, olives, and pine wood.

(2) The Durance supplies the water.

(3) It is stored in reservoirs. The distribution is effected by means of cast-iron pipes and taps, with a regulating apparatus provided with a lock.

(4) The distribution is in accordance with regulations. The quantity of water supplied is the same at all seasons. The grantees are 320 in number, and they are each allowed from one-twentieth of a module to 2½ litres per second. These concessions, which are "en location," terminate on the 21st of February, 1903.

The charge, not including the initial expense of laying on, is 120 francs per module.

(5) The climate is very mild, almost warm. The soil, being for the most part rocky, is scarcely fertile. The average rainfall is about 149.90 millimetres per annum.

(6) The inauguration of the canal took place in 1883. The commune of La Ciotat bears the expense of maintenance.

LOCATION.

(1)

Canals.	Extent of land irrigated.	Area irrigated.	Cultivable land not irrigated.
	<i>Kilometres.</i>	<i>Hectares.</i>	<i>Hectares.</i>
Canal of the Béal.....	* 2.2	129.0004	
Canal of the Béalet.....	* 2.5	36.0092	4,295.0006
Canal of La Fare.....	6.3	300.0000	1,067.0000
Canal of La Boquet.....			

* From the top.

† In course of construction.

(2) The water is supplied by the river (l'Arc).

(3) The water is secured by means of sluices in masonry. The plan of the canal of the Béal is in care of M. Alphaise (at Bèrre) proprietor of the canal. The plan of La Fare is at the Mairie of La Fare, at the archives of the syndicate. The plan of the La Bosque is in the possession of the engineer of Aix, who is director of the works.

(4) The distribution of the water is regulated by a syndicate. The average supply is 2 litres per second and per hectare for Béal and Béalet, and 1 liter for La Fare.

The concessions are perpetual.

The charge for orchards is 4 francs per hectare; meadows, 8 francs per hectare.

The canals Béalet and La Fare belong to private individuals; Béal to Monsieur Alphaise.

(5) The climate is temperate; the soil gravelly. Average rainfall at the Salins de Bèrre .502 millimetres.

(6) The canals were constructed at the end of the sixteenth century. The expenses of maintenance are regulated annually by the syndicate, and are borne by the riparian proprietors.

	Hec.	Are.	Cent.
(1) Auriol:			
Meadows and vegetables	90	0	0
Arable land (oats, olives, vines).....	1,495	60	41
Hills and heaths	2,750	5	67
Roquevaire:			
Meadows, vegetables, and vines.....	33	85	55
Arable land (wheat, olives, capers, etc.).....	1,059	5	98
Hills and heaths.....	1,237	82	10

(2) Auriol and Roquevaire are irrigated by the Huveau (river).

(3) At Auriol and Roquevaire the water is collected in a milldam by means of a sluice.

(4) The distribution of the water is regulated by the syndicate. The volume of water is irregular. M. de Remusat is the owner of the milldam.

Roquevaire: The water is distributed from Saturday 12 a. m. till Sunday 12 a. m., and is regulated by usage. It is supplied to all the riparian proprietors who bear the expense of maintenance. M. Lieutand is the owner of the milldam.

(5) Auriol: Climate, cold; soil, clayey limestone.

Roquevaire: Climate, temperate, allowing primeurs to be cultivated. There is no rain gauge in either locality.

(6) Auriol: The milldam and sluice were constructed in the fifteenth century. They are kept in order by the proprietor, M. de Remusat.

Roquevaire: The milldam and sluice were constructed in the sixteenth century. They are kept in order by the riparian proprietors.

ARLES.

(1).

Commune.	Area.	Cultivable lands.	Irrigated lands.	Extent cultivable.	Extent irrigated.	Crops.
	<i>Hectares.</i>			<i>Hectares.</i>		
Arles.....	102, 383	Arable land, cereals		14, 000		Vegetables, etc. Forage.
		Vines	Vines	8, 000		
		Gardens	Gardens	200	200	
		Meadows	Meadows	6, 000	6, 000	
		Olives		1, 500		
		Olives, etc		200		
Stes. Maries...	37, 591	Arable land, cereals		300		Vegetables, etc. Forage.
		Vines		4, 000		
		Gardens		20	20	
		Meadows		20	20	
Total				34, 240	6, 240	

In the commune of Arles the vines are submerged during the winter. The gardens are for the most part irrigated by hydraulic pumps.

(2) In the Camargue, by the Grand and Petit Rhône; in the T, by the Durance, the water is conveyed by an extension of the Chateaufrenard Canal.

In the Plan du Bourg by the Durance, the trenches of Langlade and Myrol supply the water.

In the Crau, by the Durance, the canal of Craponne supplies the water.

In Stes. Maries, by the Petit Rhône.

(3) In the Camargue, the water is obtained by tapping the Grand and Petit Rhône. The water of the Durance is conveyed to the Crau, and the Plan du Bourg by the canals of Langlade and Craponne and the ditch Myrol.

The water is distributed by means of "filioles" or secondary pipes. The plans of the Canal de Craponne can be seen at the offices of the société anonyme of the canal at Arles. Schemes for the irrigation of the Camargue are deposited at the offices of the engineer at Arles.

The distribution of the water in the canals of the Camargue are under no regulations. The water of the canals of Craponne, Langlade, and Myrol is distributed by means of dams in masonry. The quantity supplied is 1.20 litres per hectare, except during the month of March, the time of stubble cutting. The concessions are optional. The charge is 13 francs to the Craponne Company and 11 francs to the syndicate, in all 24 francs per hectare. The canals belong to private parties or to syndicates.

(5) The climate is generally dry, especially in summer, when rain is infrequent. The soil is siliceous and very pervious. That of the Camargue and the Plan du Bourg produced by alluvial deposits of the Grand and Petit Rhône is very hard siliceous limestone, and saturated with salt to a great depth.

(6) The canal of Craponne was constructed in the middle of the sixteenth century by Adam de Craponne. The canal of Langlade was made after that of Craponne, so also the ditch of Myrol.

The expense of maintenance is borne by their proprietors and the syndicates.

CHARLES B. TRAIL,
Consul.

UNITED STATES CONSULATE,
Marseilles, February 4, 1890.

[Inclosure in Consul Trall's report.—Translation of letter of Mr. Luceau, chief engineer of roads bridges Calvados.]

DEPARTMENT OF CALVADOS.

CAEN, August 30, 1889.

SIR: I beg to answer in the following order the several questions asked in your letter of the 8th instant:

(1) Calvados being a cattle-raising country since a long time the utmost has been done to utilize the water. The new demands for irrigation are therefore very rare, and it is to be supposed that the surface of the irrigable lands is already under irrigation. This surface, according to a statement made in 1870, was only 1,372 hectares (or 3,390 acres). This small proportion of the surface of the department which contains 552,000 hectares, or 1,364,544 acres), is explained by the dampness of the climate, which rather needs being made salubrious by drainage of marshes, etc., than by irrigation.

It is important to note that nearly 20,000 hectares (or 49,440 acres) are irregularly watered by flood or wild waters.

Artificial irrigation is exclusively applied to permanent meadows.

(2) The water used for irrigation comes exclusively from the streams.

(3) The works constructed on streams for the distribution of the waters used for irrigation generally consist of bars fitted with water gates able to be lifted above the highest water. These bars are authorized by a prefectural concession prescribing the dimensions and dispositions. Moreover, everybody may, after an administrative inquiry, obtain the authorization of using a stream of which he is a borderer, said water, after he has used it, to be returned to its natural course, under all reserves, however, of the rights of third parties.

(4) Nearly all irrigations in Calvados are of a private character; there are none of a collective use to report but two.

Irrigations of the small valley of Ante (arrondissement of Falaise). A decree dated February 11, 1881, rendered after inquiry, has authorized and located the establishment of sixteen bars constructed in the river Ante. A prefectural decree settled the dates and hours of irrigation for each bar. The surface of the land to be watered is 152 hectares (or 376 acres).

Irrigation of the valley of Orber within the limits of the department at Lisieux. It is not a question in fact of irrigations exclusively. The land proprietors joined in a syndical association to secure on one hand the irrigation of 286 hectares (707 acres) of meadows and on the other the working of the numerous factories situated in an industrious valley, where there are at least eighty-five streams and brooks. This syndicate is regulated by a decree dated June 18, 1864, which stipulates the use of the waters and settled the dates and hours of using the water, always considering the wants of the factories.

A syndical commission, whose members are appointed by the prefect (according to the statutes), manage gratuitously the interests of the association, the expenses are provided (for riverkeepers, printing, collecting expenses, etc.) by means of a roll rendered executory by the prefect and which is collected by the receiver of finance of the district, commissioned to that effect. By means of this roll the expenses are apportioned between the interested land owners in proportion to the value of their property. There are no fees for the use of the waters, which are common property of the adjoining landlords. The syndical associations established previous to 1865 are under the rules of the law dated June 21, 1885, modified by the recent law dated December 22, 1888.

(5) Climate damp; the yearly average rainfall is 700 millimetres (27½ inches).

Calvados soil is composed as follows:

	Hectares.	Acres.
Mountain soils, heaths, and waste lands	12,000	= 29,664
Rich soil	150,000	= 370,800
Calcareous soil	150,000	= 370,800
Gravel soil	8,500	= 21,212
Stony soil	5,000	= 12,360
Sandy soil	2,500	= 6,180
Marshy soil	70,500	= 174,276
Diverse soils	173,500	= 429,092

The most part of these soils is divided as regards agricultural purposes in 317,000 hectares (783,624 acres) arable lands and 141,000 hectares (348,550 acres) of natural and artificial meadows.

E. LUCEAU.

COGNAC.

REPORT BY CONSUL EARLE.

This part of France is quite abundantly watered; the Charente, the Nee, and many other smaller streams traverse it, and, so far as my observation extends, the question with farmers here is what to do with surplus water rather than any question of irrigation. All the canals, dikes, and ditches are exclusively for the purpose of restraining overflow or for draining wet or submerged lands. The river and creek bottoms are generally broad and level and very subject to overflow, to the great detriment of the grass planted thereon. The receding waters leave a fine deposit of mud on the stems and blades of the grass, which, drying with the hay, becomes a dust very damaging to the stock eating it. At this moment, when the new hay crop is come in to market, almost all the horses of the arrondissement are affected with a severe cough like that of hay fever.

The highlands of this arrondissement are quite out of the reach, in my judgment, of any practicable system of irrigation, nor does it require it. Some seasons are said to be very dry, but a protracted drought, I take it, is a rather rare occurrence. The principal characteristic of the climate appears to be its humidity. The night moistures or dews seem to me quite sufficient by themselves, the soil meanwhile being a little stirred, to furnish all the plant requires.

EDWARD P. EARLE,
Consul.

UNITED STATES CONSULATE,
Cognac, France, July 27, 1889.

HAVRE.

REPORT OF CONSUL DUFAIS.

I have the honor to acknowledge the receipt of the Department's circular propounding 6 questions regarding irrigation in my consular district.

This service is under the immediate management of the chief engineer of ponts et chaussées (roads and bridges) in each department of France, and under the head control of the ingénieur-en-chef, directeur de l'hydraulique agricole, M. Philippe, of the ministry of agriculteur, at Paris.

The fact that Mr. Guinette de Rochemont, the head engineer of the port of Havre, has been absent for some weeks, the only Government officer who could give me the desired information, must plead my excuse for not reporting before this. From him I learned that there is no system of irrigation in the arrondissements of Havre and Yvetot, in the Department of the Seine-Inférieure; the remainder of this department is under the management of Mr. Vivienot, chief engineer at Rouen.

The chief engineers of the departments in my consular district, besides the above named, are Mr. Sucan, at Caen; Calvados Perrin, Alençon; Orne, N. Goulon, Cherbourg; Manche L. Rousseau, Rennes;

Ille-et-Vilaine, Flouand de Fourzeroy; Laval, Mayenni, to whom I addressed myself for the required information, and, with the exception of the two first named, they very obligingly answered my questions by the letters herewith inclosed, accompanied with my translation.

If Messrs. Sucan, of Calrados, and Perrin, of Orne, should also answer my questions I will make a supplementary report; in the mean time I do not wish to delay my answer longer than absolutely necessary.

F. F. DUFAIS,
Consul.

UNITED STATES CONSULATE,
Havre, August 19, 1889.

[Translation of a letter from A. Gouton, chief engineer of roads and bridges of the Département de la Manche.]

DÉPARTEMENT DE LA MANCHE.

CHERBOURG August 17, 1889.

In answer to the request for information which you were pleased to address to me on the 8th of this month, I have the honor to say that there is very little irrigation, properly called, practiced in this department for summer watering. On the contrary the climate, which is a most temperate one, makes submersion of low meadows during the winter months, by means of brackish water, very useful.

With these general remarks, permit me to sum up the answers to questions 1 to 6 as follows:

(1) I have no data as to the extent of irrigable compared with nonirrigable or cultivated land. The very great majority of cultivated land in the department consists of pasture land for grazing cattle or of meadows furnishing mowed hay.

The quality of this pasturage is most excellent, such as that of Isigny, Bessin (neighborhood of Bayeux), Carentan (or properly called Cotentin), Valognes, etc., producing the famous butter of Isigny and Cotentin, the best in France.

(2) The water providing this rich grass in the department of Manche is almost exclusively rain water. Rains are very frequent but rarely stormy or chilling, and the average annual rainfall at Cherbourg or Isigny reaches from 1 to 1.10 metres (39½ to 42 inches). There are numerous springs, brooks, and streams, but it is only in the winter time, with rare exceptions, that lands are being overflowed.

(3) There are no reservoirs, only simple trenches for the distribution of the water on irrigated meadows.

(4) The usage of water for irrigation is regulated by common law (articles 643, 644, 645 code civil) and the laws of April 29, 1845, and July 11, 1847. Besides that, works of irrigation occasion syndical associations subject to the law of June 21, 1866.

(5) The nature of the soil is most variable in the department of Manche, presenting the greatest variety of geological formations most suitable to tillable soil.

(6) The local habit of submerging lands in the winter months in much water is very ancient; it is principally practiced on meadows and pastures near the sea, where the soil is below the level of high tides.

Winter irrigation in other regions of the Department is in the hands of individuals without either rule or coöperation.

The general service of the water courses, useful as well as detrimental to agriculture, devolves upon the Department of Ponts et Chaussées (roads and bridges) having charge of agricultural hydraulics and belong to the minister of agriculture.

Accept, etc.,

A. GOUTON.

H. Ex. 45—30

[Translation of a letter from Léon Rousseau chief engineer of the Department of Ille and Vilaine.

DEPARTMENT OF ILLE AND VILAINE.

RENNES, August 14, 1889.

SIR: Irrigation in the Department of Ille and Vilaine is of very small importance. There is in a few words my report to the minister of agriculture.

Regular irrigation, that is to say, such as permits the possibility to admit and to draw off again the waters according to the requirements of cultivation at the proper time, is extremely rare.

One single instance of this kind has been submitted to the engineers in 1888 concerning the brook Francais, on the confines of the Departments of Ille-Vilaine and Manche.

Elsewhere irrigation consists only in submersion, in consequence of the rise of brooks, of natural meadows situated in the bottoms of their valleys. The receding of the waters into their beds after freshets is facilitated by a great number of trenches dug at the confines of the several parcels of fields or traced according to the depressions of the soil.

Submersions are also practiced in some dried-up ponds, which have been transformed into meadows. These ponds having been drained by breaching a dike or highway to allow the water to run off. The system of irrigation consists in temporarily stopping up such breach to allow the water to rise and to overflow the neighboring fields.

LÉON ROUSSEAU,
Chief Engineer of Roads and Bridges, Ille and Vilaine.

[Translation of a letter from Mr. Flouand de Fourzeroy, Chief Engineer of Roads and Bridges, Department of Mayenne.]

DEPARTMENT OF MAYENNE.

LAVAL, August 10, 1889.

SIR: You were pleased to send me an interrogatory regarding irrigation. I should have been happy to answer it, as far as this department is concerned, but it would be difficult to do so in a precise manner.

Irrigation is frequent in this department, where the soil is very much broken and divided into a great many small and rapid water courses, where it is easy to construct small dams and to turn the water into trenches to irrigate numerous natural meadows; but there are no statistics existing to state the extent of land susceptible of irrigation, compared with such as is non-susceptible. There are no reservoirs. There is only one syndical association, of small importance, occupying itself principally with the draining of meadows, with the view of making them salubrious.

The climate is rather rainy, the subsoil impervious; there are no extended or deep valleys, neither are there table-lands or heaths. On the whole, I do not believe that the interrogatory, which you did me the honor of addressing to me, can be answered in an interesting or precise manner.

Accept, etc.,

FILOAND DE FOURZEROT.

NICE.

REPORT BY CONSUL HATHEWAY.

AREA IRRIGATED.

In compliance with the requirements of circular, dated May 2, 1889, I have the honor to report as follows:

The lands of this district under irrigation are so detached and inconsiderable that I find it difficult to obtain a definite estimate of the area thus treated. Irrigation here is applied, for the most part, to ornamental, horticultural, and vegetable gardens, instead of to fields of general agriculture, and to no grain lands whatever, and in but small

extent to the vineyards and orchards of orange, lemon, and olive. The expense for flowage water procured from the hydraulic works of the city of Nice render such use largely unprofitable and the scarcity of the natural supply precludes its systematic application to any wide degree, except in the valleys of the Var and lesser rivers. Where irrigation here is practiced, production is doubled without injury to the quality of the crop. Sterile soils, long useless, recover and yield abundantly, and in many localities to insure valuable returns to the husbandman it is of absolute necessity.

WATER SOURCES.

The ordinary sources of water for the purpose are ancient wells, from which during hours in each day it is drawn by mule power and quite primitive machinery into distributing tanks and proprietary springs in favored spots, and the streams and rivers of the country, at times torrentially full, but of skrunken, partially exhausted currents in the heats of summer. There are no important private storage works for irrigation proper. The new "*Compagnie Générale Des Eaux*," supplying the city of Nice and its neighboring towns and villages along the Littoral, has an excess of water available for irrigation, but its rental for the general requirements of agriculture, is so excessive that in most cases it is destruction to the profit of the user. Further than this, however, the farmers possess great complacency as a trait; the old ways of their fathers are quite good enough for them. They regard experimental undertakings with disfavor and yield reluctantly to any change in their customs and inherited slow, patient methods of labor.

The said company having obtained a concession, with an appropriation therewith of 2½ millions from the State, was organized in 1878, and its works established at a cost of 12,000,000 francs. Its supply is obtained from the river Vesubie, in the valley of that name, distant about 30 miles from Nice, from which river it is led, flowing at the rate of 4,000 litres each second, in an open cemented canal to a distributing reservoir on the heights in the suburbs of said city.

In its treaty with Nice, the company is bound to supply the city, for the annual payment of 80,000 francs, with 60,000 cubic metres of water daily, for its abattoirs, sewers, fountains, and public works. The water for domestic uses, also provided by said company, is derived from a separate source, viz, the mountain springs of "*Sanite Thècle*." Under the aforesaid concession from the State, the company covenants during the term thereof, viz, until 1972, to maintain the construction of their works for the public utility of the region and to furnish flowage at fixed prices therein stipulated. Otherwise than this, said corporation is unsubjected generally to the Government control. The established tariff for its continued use for irrigation on ordinary levels, is as follows, viz, for 1 cubic litre per day, annually, 30 francs; for 2 cubic litres per day, annually, 50 francs; for 3 cubic litres per day, annually, 60 francs, and for each additional daily cubic litre, 20 francs annually. The tariff for its periodical use is proportionate to the above table, conditioned, however, to an agreement as to quantity to be consumed. The service pipes are in all cases at the charge of the proprietor.

SOIL AND CLIMATE.

The region having thus facilities of irrigation is by nature restricted to the foot hills and narrow valleys of this district, beyond and above which are the mountains barren of or discouraging to cultiva-

tion. The climate owing to the configuration of the coast, the new counterforts of Alps, and the proximity of the sea; which serves as a vast reflector of the sunbeams, is semitropical in character. The soil, producing two or more variable crops a year, is alluvial, with a humous surface, and a gravelly substratum, and quickly absorbs all moisture. In May the temperature averages 64°, in June 70°, and in July and August 78° F. In winter it averages 52° F.

From May to November more than 100 days are usually without clouds.

The average rainfall is from 8 to 100 centimetres per annum.

ALBERT N. HATHEWAY,
Consul.

UNITED STATES CONSULATE,
Nice, August 23, 1889.

HOLLAND.

REPORT BY VICE-CONSUL VINKE, OF AMSTERDAM.

There are, as far as I am aware, no instances of irrigation, properly so called, in application in the Netherlands.

By far the largest proportion of pasture and arable land in this country is more than amply supplied with water, being intersected with rivers, canals, and waterways in every possible direction.

As the beds of these rivers and canals are in many instances above the level of the surrounding country, it is an easy and simple matter to flood the surrounding meadows when required, which is generally done when necessary in the winter and spring months; the surplus water being subsequently pumped back into the river or canal by wind or steam power.

A large proportion of the inner part of the country consists, however, of sandy mire and heath, and constant efforts are being made to reclaim this ground, but up to the present such efforts have been principally directed to the cultivation of timber.

ALB. VINKE,
Vice and Deputy Consul.

UNITED STATES CONSULATE,
Amsterdam, August 27, 1889.

REPORT BY CONSUL ELLIS, OF ROTTERDAM.

Lands in Holland have been reclaimed from the sea by building great dikes to keep out the water. There are here no arid lands which are irrigated.

That the farms near the rivers in dry seasons are supplied with water through the canals without any charge being made therefor.

That the farmers in Holland suffer from an excess of water on their lauds, and that each farmer has the use of a mill (windmill) to pump out the water from their lands into the canals and rivers.

That there is no storage of water for the purposes of irrigation, and that the annual rainfall is excessive as compared with any other country.

I beg to add that the wonderful development of this country by reason of the full supply of water at all times for agricultural purposes gives us a most valuable suggestion for the treatment of arid lands, for we have everywhere great rivers which may be turned in upon lands lower than their flows, and from which water may be turned into reservoirs to be distributed by use of proper power upon higher lands. In respect to my last remark, let me suggest that the adaptation of the windmill, found to be so serviceable in Holland to get rid of surplus water, to the purpose of pumping water to higher levels, every farmer then could have for his own use the necessary power to serve him. However, with respect to this, American pumps are highly considered here, and I must assume that there will be no difficulty in distributing the water if you can build the reservoirs and fill them.

HOWARD ELLIS,
Consul.

UNITED STATES CONSULATE,
Rotterdam, Netherlands, October 7, 1889.

ITALY.

GENOA.

REPORT BY CONSUL FLETCHER.

Little can be learned on said subject in this consular district, for irrigation is not practiced here, neither does the territory composing the district require it or admit of it, for reasons given below.

This district, namely, between Spezia and Genoa on the east coast, and between Genoa and Ventimiglia, on the west coast, is very mountainous and it has but very little tillable soil. Indeed, it is estimated that only about one-fifth of the entire district is capable of cultivation, and this one fifth, owing to very irregular formation of the country, is divided into thousands of small plats scattered here and there like so many small dots, so to speak, along the mountain sides and seacoast.

Springs, small streams, and rivers are plentiful in this consular district, and the tillable land is what the people call *string*, that is, a soil which retains moisture a long time, and whenever these small tracts require watering, which is not often the case, the springs, streams, and rivers supply the demand with the owner's assistance.

JAMES FLETCHER,
Consul.

UNITED STATES CONSULATE,
Genoa, Italy, July 31, 1889.

NAPLES.

REPORT BY CONSUL CAMPHAUSEN.

I have the honor to report that on receipt of your circular, instructing me to furnish information on the subject of irrigation as practiced in this country, I immediately applied for statistics to the prefects of the ten provinces composing this consular district, who kindly replied

that owing to the scarcity of water-courses, there were no lands under irrigation in their respective provinces. It is claimed that the geological and lithological conditions of the country are such that it would be impossible to carry any system of irrigation into effect.

This country depends absolutely on the rain falling mainly during the months from November to April. The average annual rainfall is said to be about 20 inches. There are some lands under private irrigation. The water supply belonging to the respective land owners is taken from wells at a depth varying from 25 to 100 feet, water being found in abundance at that depth in most parts of the country. Near the coasts of the Adriatic and Mediterranean wells are formed by the infiltration of saltwater. Some of these belong to communities, but no definite law or regulations appear to exist for the use or distribution of the water, and there is no irrigated land in the true sense of the word in this district. I inclose a copy of the law concerning the derivation of public waters, and also a publication discussing a project for supplying the province of Bari with water for domestic purposes.

EDWARD CAMPHAUSEN,
Consul.

UNITED STATES CONSULATE,
Naples, Italy, September 5, 1889.

PALERMO.

REPORT BY CONSUL CARROLL.

INTRODUCTORY REMARKS.

I have the honor to inclose herein rather imperfect replies to the questions propounded as to the system of irrigation obtaining in this province, there being none worthy of mention in the other provinces embraced in this district. Prior to 1866 the water for irrigation was owned by private individuals, the municipality, and convents or religious corporations.

In that year, however, the government confiscated all the property of the latter to which there was a clear title or in which no outsider, public or private individual, had an interest, so that now it controls all the water formerly owned by the religious bodies in question, which by far exceeded that owned by the municipality and private persons combined. This water the government either sells or rents.

There appears to be little or nothing of interest in the means employed in irrigation here, so far as I can see and learn, and it is not therefore deemed proper to dwell at length upon the matter.

REPLIES TO CIRCULAR.

Area irrigated.—There are 508,601 hectares of land embraced in the province of Palermo, of which one-fortieth is cultivable and irrigable. Nearly 176,000 hectares are under irrigation, yielding on the average an eighth per cent. crop.

Water supply.—Water is derived principally from deep wells, pumps, and reservoirs, the latter being supplied by means of earthen and iron tubes or pipes communicating with the adjacent mountains, as well as by rivers, streams, springs, and falls, in a very limited degree during

certain months of the year. The supply of spring water is, however, said to be decreasing.

Water distribution.—The distribution of water is governed by its owners, viz, the municipality, the government, and private individuals, and is based upon the measures adopted by the municipality of Palermo centuries ago. The amount of water used on the average is from 300 to 350 cubic metres per hectare of land.

By the system in vogue nearly 17 litres of water can be conveyed to a designated point per second, and an area containing nearly 13 acres can be irrigated weekly, the charge therefor being 5 litres per hour.

Irrigation is commenced on April 15, and terminates September 15, annually. For obvious reasons it is not resorted to during the winter, excepting in prairie lands, for promoting the development of grass.

Climate and soil.—The average annual temperature of the province of Palermo is 17° centigrade.

In the mountainous regions the climate is temperate and on the sea-coast very warm.

A characteristic of the province is the almost absolute absence of rain from May to September.

The average annual rainfall of the province is 59 centimetres. Rain later than May is rare and generally meager, and should the usual copious spring rains fail to make their appearance crops suffer severely.

Antiquity of irrigation.—As stated the present system, consisting of pumps, wells, falls, reservoirs, etc., has obtained for centuries under the auspices of the municipality of Palermo, monasteries, and private persons, but since 1866 the government has controlled the water belonging to religious bodies, it having in that year confiscated all property belonging thereto. The government either sells or rents this water. The expense is defrayed by the respective owners.

PHILIP CARROLL,
Consul.

UNITED STATES CONSULATE,
Palermo, Italy, October 7, 1889.

MESSINA.

REPORT BY CONSUL JONES.

ANTIQUITY OF IRRIGATION.

Irrigation in Sicily dates from the occupation of the island by the Mussulmans. They took possession of Palermo in 831 and gradually extended their sway. Ruins of the Emir's castles, agricultural terms still in use relating particularly to irrigation, and numerous African plants, all testify to their former presence here. In the year 872 they first began the use of the "noria" (Senie), raising well water into water towers (giarraton) or cisterns (giabiat), whence it was distributed by means of small ditches (sajat), and this is the system in general use to-day.

Irrigation did not obtain the same development in this province as in that of Palermo, for the reason that water veins are not as numerous here.

Since 1850 the search for water has been steadily on the increase, due to new methods of reaching it (by drilling) and of raising it (by endless chains of iron buckets instead of the old-fashioned noria with

paddles) and to improved gearing. Water is pumped up, and many of the wells are 100 feet deep and over, by horse-power; oxen are also much used for this work, and occasionally by steam-power. There is no coal in Sicily and the lack of roads makes its transportation from the seashore too expensive.

According to the Italian civil code all water under the beds of rivers or torrents belongs to the State; but while this is the law it happens, nevertheless, that owners of land along the water courses use the water with more or less immensity, so that but a small quantity may be said actually to belong to the public domain.

Water supply.—The supply of water for irrigating purposes in this province is small. The extremely mountainous district of Val Demone is not adapted to the percolation of rain water, particularly as a short-sighted policy has destroyed the natural reservoirs, the forests thus permitting the rain to run off and waste. As a result not a single river is to be found in the province, but we meet at every hand destructive torrents, their beds are dry in the summer, whose havoc is ever on the increase. There are no less than thirty torrents in a stretch of country 45 miles wide in this province. Natural springs are but few, so that the greater portion of the water used for irrigation as well as for drinking purposes is obtained by means of costly hydraulic works, tunnels, wells, cisterns.

The topography of the Messina district does not allow of the formation of lakes, and with the exception of two small brakish sheets of water near the Faro and of a fresh-water pond in the commune of Roccella Val Demone, we find no lakes here.

Area irrigated.

Owing to the deficiency in the water supply and to the greater portion of this district being mountainous but one-sixteenth of the total cultivable area (14,000 hectares) is irrigated. The irrigated area is occupied as follows:

	Hectares.
Oranges and lemons.....	7,600
Market gardens*.....	800
Flax and hemp.....	200
Indian corn.....	1,000
Legumes (beans).....	1,400
Fruit trees (peaches, pears, etc.)	500
Reed cane.....	2,000
Marshes.....	500
Total.....	14,000

Irrigated land produces crops not only superior as to quality but threefold as to quantity compared with nonirrigated. Irrigated open land sells for three times as much as the nonirrigated; near the city of Messina it fetches from \$780 to \$1,230 per acre.

MODE OF IRRIGATION.

The water is pumped into well-cemented reservoirs or vats, generally prismatic in form (because cheaper), rarely circular. We also meet with covered cisterns. From the "collecting" reservoir the water is made to

* It should be added that garden truck is very generally cultivated in the vacant spaces in orange and lemon groves.

pass into the "distributing" reservoir through gutters called "condotti" or "tubi," conduits or pipes. The water is carried from the distributing reservoir to different parts of the grove, either by trenches called "sajat," or by brick conduits, either closed or open on top; the latter are known as "brinsi."



Section of "brinso."

The open conduits are to be preferred, because they do not choke and because they are not liable to burst.

Should the grove be extensive, small distributing reservoirs, called "cisternoli," are established here and there.

WATER DISTRIBUTION.

This distributing of water for irrigation purposes when the water is private property (for by law the owner is allowed to make what use of it he pleases provided he does no damage to his neighbors) is not governed by law, but by special customs that vary with the locality and which it would be impossible to enumerate. The cost of water for irrigation purposes is so complicated a matter that it can not be fixed precisely, but this much can be said: In this province a penna (a goose quill) of water, i. e., 36 gallons of water per hour costs from \$200 to \$260 per annum.

Here, as a rule, water is private property. Some communes own water, either by purchase from private parties or because its source is on community land.

The title to water is acquired by bargain and sale, exchange, gift, and can also be acquired by prescription. Not less than 30 years of undisturbed enjoyment are necessary to create title by prescription.

CLIMATE.

As to the climate of the province, the maximum of heat is 87° F. Some winters the thermometer falls to 2 degrees below freezing, but this temperature prevails but for a very short period. Snow covers the tops of the mountains for several months during the winter, and nearly every year reaches the seashore, covering the ground for a few hours. At Messina the temperature changes with the currents (which are tidal) that pass through the straits. From October to December it rains frequently; in January and February it rains and snows; in March and April it rains constantly. Open weather begins in May and lasts to September, with an occasional heavy down-pour. Annual rainfall, 22 inches. During the spring and autumn months fogs prevail on the mountains; it rarely hails; dew and white frost occur frequently. Frost in April inflicts considerable damage.

No hydrographic maps or publications bearing upon irrigation in this province exist. Less attention has been paid to irrigation in Sicily than in any other portion of Italy; but little progress has been made since

the days of the Arabs. A few years ago a technical school for instruction in hydraulics was opened in Palermo. If the water of the numerous torrents in Sicily were to be controlled and utilized in irrigation, many localities now infested by pernicious and malarial fever would become healthy and habitable. Statistics show that one-fifth of this island is subject to the influence of stagnant water and of the dry beds of torrents during the summer, and the organic matter accumulated for centuries in these low spots breeds foul emanations that poison the air.

IRRIGATION WORKS.

No works for the storage and distribution of water have as yet been undertaken by the Government in Sicily. In 1858 a company with a capital of \$150,000 undertook, under a charter from the Bourbon Government, to utilize the water of the river Simeto in irrigating a portion of the plain of Catania, the total area of which is 65,506 acres. A rough stone dam was thrown across the river at Paterno, and two principal canals, one to the right (20,000 yards long) and the other to the left (30,000 yards long) of the river bed were opened down to the ocean. Four secondary canals (leading from the principal canals) were also opened, and these were intersected by numerous irrigation ditches, the latter of a total length of 10,000 yards. The banks of the canals are faced with stone or with logs wherever the land has a tendency to slide. At the dams the canals are 6 feet wide at bottom, 29 feet wide at top, and 6 feet deep; the banks have an incline of 45 degrees. The dimensions of the canals decrease as you go from the dam. The depth of water in main canals should never exceed $4\frac{1}{2}$ feet. The average mean amount of water that passes through the canals is 722 gallons per second. The company charges \$67 per 7 gallons a second from April 1 to October 1, and \$33.50 from October 1 to April 1.

In the plain of Catania, on a calcareo-argillaceous soil, wheat, legumes, and flax require $4\frac{1}{2}$ inches of water from October to April. Summer pasture lands require 12 inches of water. The very stiff clay lands in this plain appear to be adapted to rice culture only. Quite an area is so flat that the water ponds on the land, and the slime left by the water impoverishes the land and makes it more difficult to cultivate. This undertaking has been a failure financially; not only has the original capital been sunk, but a debt of \$120,000 hangs over the company.

The only other work of importance in Sicily connected with irrigation is the dam $2\frac{1}{2}$ miles above Terranova, province of Caltanissetta. This massive stone dam is 360 feet long, 24 feet wide at the base, 15 feet wide at the top, and 30 feet high, and was thrown across the river Gela at a cost of \$85,000 by the wealthy Duke of Monteleone, descendant and heir of the great Cortès, as far back as the year 1788. An irrigation canal leads out from either wing of the dam; area irrigated, 11,860 acres. Below the dam the water falls on a stone platform 138 feet wide by 123 long and then follows its old bed to the sea. At the point where this dam is erected the river runs through a gorge, the sides of which constitute natural stone walls. An elliptical gap 80 feet wide by 10 feet deep has been left towards the middle of the dam. At this point fascines are thrown against the dam on the water side, and earth is thrown on the fascines, constituting, as it were, a floating island, the surface of which is brought almost to a level with the dam on either side of it. Pistachio trees, tamarisk shrubs, and grass are set to grow on this island, which serves as a tumbling dam. As the

water rises it gradually runs off, overflowing the island, which in times of a strong freshet is carried away bodily. It costs \$500 per annum to keep up this island; it would cost \$800 to replace it. The land irrigated by means of this dam produced from 1862 to 1865 5,000 bales of cotton (of 450 pounds) per annum. Cotton is still grown for home wants on a small scale.

Since 1865 the Italian Government has expended large sums in draining marshes, lakes, and ponds, and in controlling the course of rivers and torrents in northern and central Italy. Valuable documents, not for sale, however, treating of these works have been published by the minister of public works. As yet no Government report has been published treating of works of irrigation, and to get at figures it would be necessary to apply to the several prefectures of the several provinces.

By the law of 25th December, 1883, the Government is empowered to loan funds (principal payable in 30 years) at 3 per cent. to "irrigation associations" (consorzi) and to provinces and communes for the purpose of carrying on works of irrigation; provided the supply of water to be obtained shall be not less than 25 gallons per second, and provided the province or commune advances an amount at least equal to one-tenth of the sum loaned by the state.

WALLACE S. JONES,
Consul.

UNITED STATES CONSULATE,
Messina, September, 1889.

SICILY.

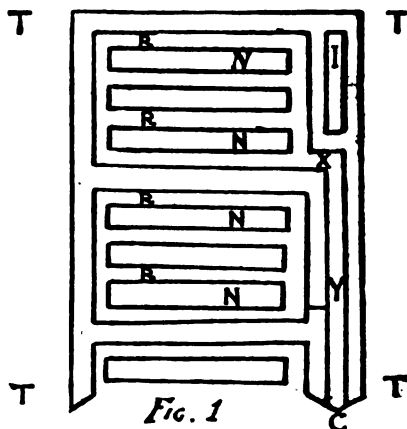
REPORT BY CONSUL JONES OF MESSINA.

IRRIGATION OF ORANGE AND LEMON GROVES.

In Sicily, generally speaking, no attempt is made to grow oranges or lemons unless it be possible to water the trees during the summer months. There are, however, favored spots (for instance, near Aci Reale, 40 miles south of Messina) where, owing to water veins in the subsoil, the trees retain their vigor during the summer. The proportion of nonirrigated to irrigated groves is as 1 to 15 (in extent). One hundred 10-year old lemon trees that are watered produce on an average 15,000 lemons; whereas 100 trees that receive no water (other conditions being equal) produce but 10,000, or one-third less.

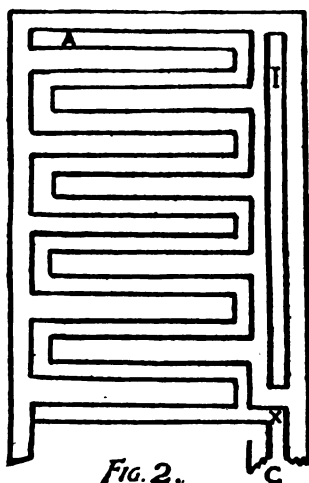
The groves are watered from twelve to twenty-five times during the summer, *i. e.*, either once every two weeks or once a week, and at each watering at least 350 cubic metres should be allowed to the hectare (2.47 acres). At the last spring working of the trees the land is trenched, in order to obtain an equal distribution of the water. Parallel trenches are opened (generally about 6 inches deep and 8 inches wide at the bottom) between the rows of trees, the intermediate space being divided into symmetrical squares or divisions.

To illustrate: Let us suppose the land to be laid off as in figure 1. T

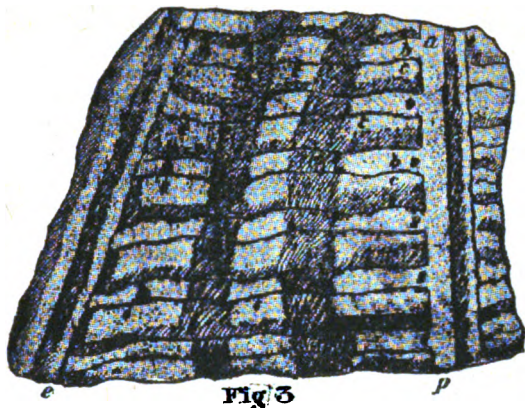


TTT ridge surrounding a section of the grove. NNNN beds alternating with the furrows RRRR permit the circulation of the water, which, entering through the channel *OI*, is diverted from its course by hauling down the ridge at *X* and made to run into the furrows RRRR. The opening at *X* is closed, and the water is now turned in at *Y*, and so on. By this method the water distributes itself equally, saturating the beds NNNN, which retain the water near the roots of trees, retarding evaporation.

If the grove be situated on a rather steep hillside, the water will be made to follow the furrows (as in figure 2) *RR* serpentine fashion, otherwise it would run off too rapidly and cause washes.



If the grove occupy undulating ground the water furrows would be made to assume a sinuous course, somewhat as represented in figure 3.



If the grove be very level, the water is carried from the distributing reservoir by lines of brick pipes (*brinzi*), open on top, resting on narrow stone walls built with the necessary incline to reach the most distant point from the reservoir.

The above system applies to the irrigation of groves where the water supply is abundant and is derived from a stream or spring. Oftentimes when the water must be pumped up by horse-power the tenant, unless it be otherwise stipulated in the contract, will so arrange his trenches as to collect the water in a basin at the foot of the trees. This method is not to be commended, for it retards the development of the fruit, of the lemons more especially, and predisposes to *gum* or foot-rot.

One-year old orange or lemon trees should be watered once a week, 3-year old require water once every twelve days, from the fourth to eighth year once every two weeks. With the bergamot, however, weekly irrigation is required during the life of the tree.

It is always preferable to irrigate during nighttime. Isolated trees are sometimes watered by sinking an earthen pipe (3 feet long by 4 inches in diameter) not far from the trees, and filling the same with water. This method has the advantage of causing the tree to send its roots down. The beds of the torrents suck down the water from the springs on the hillsides. To bring this water to the surface oblique ditches are cut across the torrent beds down to the water veins, and a drain, provided with numerous loop-holes, in masonry, is put in to collect the water. These drains, following more or less the trend of the land, carry the water into the groves to the right and left.

Bastard fruit, *i. e.*, fruit maturing out of season, always commands good prices; hence it frequently happens that tenants allow the trees to go without water during June and July (the trees suffer badly, the leaves turn yellow and there is great loss of vitality), and begin watering heavily and frequently in August to force the trees to put on blooms in September, and in that way produce late fruit.

WALLACE S. JONES,
Consul.

UNITED STATES CONSULATE,
Messina, September 13, 1889.

SICILY.

CATANIA, CALLANISSETTA, AND SYRACUSE.

REPORT BY CONSUL LAMANTIA, OF CATANIA.

This consular district comprises the provinces of Catania, Caltanissetta, and Syracuse, and their areas are as follows :

Province of—	Square kilometres.
Catania	5, 102. 19
Caltanissetta	3, 768. 27
Syracuse	3, 696. 12

There are several rivers in said provinces, the Simeto and Salso, which are the largest ones in Sicily, but none navigable.

PROVINCE OF CATANIA.

Area irrigated.—This province, with an area of 3,298 square miles, has only 988,000 acres of cultivated land, 20,000 acres of which are regularly irrigated, viz :

	Acres.
Orange gardens	7, 410
Kitchen gardens	7, 904
Rice plantations	1, 235
Indian corn fields	1, 235

Cornfields and vineyards are also watered, but in cases only of great drought, and when the land is in condition of being irrigated. The produce obtained of said 20,000 acres of irrigated land, are as follows : Orange groves, 471,900,000 oranges and lemons ; kitchen gardens, several quantities and qualities of vegetables ; rice plantations, 4,160 bushels of rice ; cornfields, 2,000 bushels of corn.

Water supply.—The water used for irrigation is derived from natural and artificial springs and rivers.

The orange gardens are chiefly watered by artificial springs, namely, where the locality is adapted, wells are dug and the water elevated by pumps worked by steam or animal power.

The orange gardens, both in the piana or lowland of Catania and near the River Alcantara, get their water from said river and from the River Simeto. But the greatest part of the fruit gardens of Paterno, Aderno, and Calatabiano are also irrigated by natural springs which discharge abundantly at the foot of Mount Etna. The land used for kitchen gardening is equally watered by natural springs or artificial wells ; the rice fields and corn plantations, which are only in the Plain of Catania, by the River Simeto.

Water distribution.—For the water of the Simeto there is a company which rules the distribution of water and collects the duty (rental). Said company obtained a concession by the Bourbon government in 1852, with appropriate regulation. But in order to utilize said waters in a more rational and practical system a new company is going to start up with the view of distributing the waters in accordance with the prescriptions of the new law just issued by the Italian Government for the utilization of the waters for irrigation purposes. The rivers are national property, but the distributing of the water of the Simeto, as above stated, is ruled by the said company. For the waters obtained by artificial wells the law has made no special provisions, as the person who has dug

them for his own purposes and at his own expense is the only proprietor. The natural springs are also without exception of private property, and consequently the water of the same is issued, sold, or granted at the owner's pleasure.

The water of the Simeto is sold by the above-mentioned company, at the following conditions:

In summer time, from April 1, to September 30, 336 lire for a *zappa*, equal to 4,400 gallons (Sicilian measure) or \$65 for said gallons. In the winter months, however, it is sold at half price of the above rate.

The quantity of water consumed per acre of land changes according to the quantity of water disposed of and according to season. The mean consume per acre of land used for kitchen gardening is about 1 gallon per second.

For rice cultivation, the consume of water rises up to 2,641 gallons per second.

For orange gardens there are no fixed rules, but according to the drought of the weather during the summer months. From one to ten irrigations are made in the hot season, and parties who have no contract with the Simeto company pay for the water at the rate of \$6 per *zappa* for each irrigation.

Climate.—It is impossible to state exactly the influence of irrigation on the climate, because in this district there are no extensive tracts of irrigated and non-irrigated land, and as these two species of land are connected together each as well. But generally it may be said, that irrigation renders the climate milder, for it allows the earth to be constantly cultivated and covered with plants which appease largely the summer heat.

Rainfall.—The mean annual rainfall in this district is 50 to 60 centimetres, with 60 centimetres of rainfall the springs give sufficient produce; but in years when the rainfall is from 40 to 45 centimetres only, many springs get dried up with great damage to the cultivation.

Simeto artificial canal.—As above stated, the irrigating system in this consular district is by use of water derived from rivers, natural and artificial springs, and canals.

The Simeto has its sources on the Mounts Nebrodi, not far from the Etna, runs through the province of Catania, and after having been swollen up by the waters of several torrents, and by the Dittaino and Gornalunga Rivers, empties itself into the Ionian Sea, at 15 kilometres of the city of Catania.

It was not later than the 16th of March, 1852, that by decree of the Government, a company was organized with the view of utilizing the waters of the Simeto.

A dike was raised near Paterno, about 18 kilometres far from Catania, where the river embanking in the rock makes the locality well adapted for canalizing the water.

The most important works built for the utilization of said waters consist of two large canals at both sides of the river, and of four smaller canals connected with the first two, which at a distance of 500 metres are joined together with the ditches for the distribution of the water to private estates.

In the mouth of the right-hand canal there is a strong drain, which is provided with three openings of rectangular shape, 1.03 metres wide by 1.29 metres high, which are closed by iron partitions set in the building itself.

Each partition has a screw provided with a long key, by means of which it can be raised or lowered, according to the quantity of water existing.

From the dike to the said drain there is a distance of 132.15 metres and an equal distance exists between the dike and the drain of the left-hand canal, which is provided with only one postern. This last-named canal, 30 kilometres long, near the railway station Motta S. Anastasia, has a waterfall of sixty-dynamo horse power, and it is also provided with numerous smaller canals for the distribution of water.

The right-hand canal runs on by the plain of Gerbino, watering the land at the left-hand of the Dittaino River, and has also a waterfall, by which two mills are worked, giving yearly rental of 2,500 liras.

The water obtained by these works is of about 62,381,000 gallons per day of twenty-four hours, but double this quantity might be given, should agriculture require it.

In summer season, from the 1st of April to the 31st of September, the water is sold at the rate of \$65 per 4,400 gallons. In winter time, from the 1st of October to the 1st of April, the price is lowered to \$32.50 per 4,400 gallons.

For consumption in the summer months the water is generally leased to the proprietors by contracts for thirty years, which give a yearly rental of 750 liras, not including the leases for twelve months only.

In winter time the water is distributed by turn, once a month, at the rate of \$5 per 4,400 gallons.

The part of country irrigated by the Simeto extends to the left hand of the river, the canals stretching as far as the city of Catania, all the canals irrigating about 100 square miles. The hills near Motta and Misterbianco, by means of said waters have been reduced into luxuriant orange gardens and orchards, but the lowlands, owing to the argillaceous nature of the ground, although under irrigation, are used as corn and cotton plantations only.

The quantity of land under irrigation all over Sicily is shown by the following table, made in 1865, by Prof. F. Alfonso. But it is to be noted that since 1865 the greatest progress has been made in every branch of culture, and the hydraulic works in this island have been numerous as is testified by the many new or ange gardens, orchards, and kitchen gardens, as it results from the information given to me by competent men.

Irrigated lands in Sicily in 1865.

Province.	By rivers.	By canals.	By springs.	Total surface.
	<i>Hectares.</i>	<i>Hectares.</i>	<i>Hectares.</i>	<i>Hectares.</i>
Palermo	2,614	767	452	3,833
Messina	1,359	1,101	2,228	4,688
Catania	2,701	612	5,089	8,402
Syracuse	4,985	2,581	2,207	9,722
Caltanissetta	709	3,577	522	4,808
Girgenti	550	142	967	1,679
Trapani	218	131	777	1,126
Total	13,886	8,911	12,262	34,259

In the provinces of Piedmont and Lombardy, however, the volume of waters supplied from rivers, canals, and springs is greatly larger than the above provinces, as is shown by the following tables:

Irrigated lands in Piedmont in 1865.

Province.	By rivers.	By canals.	By springs.	Total surface.
	<i>Hectares.</i>	<i>Hectares.</i>	<i>Hectares.</i>	<i>Hectares.</i>
Cuneo	15, 246	72, 694	24, 243	112, 183
Torino	15, 855	77, 667	81, 246	124, 768
Alessandria	781	8, 749	855	10, 885
Novara	13, 123	82, 412	11, 731	107, 266
Total	45, 005	241, 522	60, 075	*354, 602

Irrigated lands in Lombardy in 1865.

Province.	By rivers.	By canals.	By springs.	Total surface.
	<i>Hectares.</i>	<i>Hectares.</i>	<i>Hectares.</i>	<i>Hectares.</i>
Pavia	5, 708	62, 926	18, 630	87, 259
Milano	61, 867	109, 373	23, 177	194, 417
Como	1, 391	163	1, 124	2, 678
Sondrio	8, 000	.....	400	8, 400
Bergamo	27, 317	23, 716	2, 435	54, 468
Brescia	1, 241	58, 822	49, 008	109, 071
Cremona	1, 425	76, 238	54, 262	131, 925
Total	106, 944	328, 238	150, 036	*588, 218

*Data formulated by Marquis R. Pareto.

PROVINCE OF CALTANISSETTA.

Terranova Dikes.—In 1788 a dike was constructed through the river Gela (about 4 miles from the town of Terranova) by the Duke of Monteleone, who owned large estates in that territory.

The said dike consists of a strong, massive wall, 120 metres long by 7.74 metres wide, by 10.32 metres high, and has on its center a semi-elliptical lunar course with the greatest axis of 27.10 metres, and the shortest of 3.61 metres, which has the purpose of avoiding the overflow of the flood waters.

Each of the two inner edges of the dike is protected by a converging wall, the east one of which has a length of 183 metres, whilst the west one is 139.37 metres only. The waters stopped in their course by the dike, finding no outlet, owing to their being checked on both two sides by said walls, on reaching the height of 10.32 metres flow into the two canals for their distribution to irrigable lands.

In the aforementioned lunar course the farmers construct a work of fascines and earth, sufficiently strong to stand the ordinary shock of the waters before they find their way into the canals; but during the winter floods, when the current of the stream swollen by the rainfalls becomes dashing, the said work of fascines is often carried away by the rush of the waters, so that the semielliptical lunar course, having no protection, affords a free passage to their impetuosity over the dike, avoiding such damages as might be caused by the overpressure of the floods, which fall from a height of 10.32 metres on the exterior platform of strong masonry work, 46.48 metres wide, 36.40 metres long, shown in the annexed drawing. The said work of fascines and earth is generally built when the current of the stream is rather scarce and it has also the purpose of regulating the outlet of the water according to

the need. The said work ends at the same height of the dike, and about its center is somewhat depressed for the passage of the water. The results obtained by this hydraulic work have been of the greatest importance for all those landowners who are in favorable condition for irrigating their estates.

The look of the land under irrigation changed totally, as by spell, and all classes of people found profitable occupation by the development of the cotton plantation, which gave a yearly mean produce of about 1,000 tons of cotton.

PROVINCE OF PALERMO.

Reservoirs.—In the highlands and hilly grounds, where it is impossible to have springs, science advises the construction of such works, which may stop the rain water running in the winter time in the ravines and then use it in the summer time for agricultural purposes.

By this device the artificial reservoirs (so common in Italy) all constructed molded as the ancient ones of the Asiatics and Romans, which later on, introduced by the Moors in Spain, took the name of pantanos. Notwithstanding there are no reservoirs in this consular district, yet I may give an account of several of them worthy of mention in this island, in the province of Palermo, not far from the city. A reservoir of this kind, constructed in the last century in one of the estates once belonging to the Prince of Lampedusa, is still to be seen near Palermo and bears the name of Billiemi Reservoir.

The same consists of a massive building 26.84 metres long by 2.06 wide by 2.57 high, and is constructed in the gorge of a ravine, on solid calcareous soil.

On the exterior, viz, on the lower part of the ravine, the dike is strengthened by four stout pillars, and on its interior are to be seen two walls 31.74 metres long by .51 wide, which stand to it in right angle, inclosing an area of 8.18.56 ares, and which can contain 28.191 hectolitres of water (6,188,000 gallons).

The two extremities of the dike on their superior part have a canal, which has the object of giving free passage to the superabundant water, without damaging the edges of the dike which, after so many years, should have been corroded.

About the center of the bottom of the dike there is poured the water and the sediments of this latter when the reservoir is void.

Another reservoir of considerable dimensions, called "Godrano," is near the village of Mezzojuso, in the neighborhood of Palermo. The same has a length of 119 meters, a width of 91 meters, occupying an area of 1.27 hectares—3½ acres.

This reservoir, although the most capacious in Sicily, is still very far from the dimension of its brethren in Piedmont and Lombardy.

In conclusion, I must state that reservoirs of river or spring water are of the greatest help to agriculture in Sicily, for by their help are utilized the waters of such small springs, and other sources which prove not sufficient to irrigate the fields without artificial help.

I could obtain no plans of said reservoirs, but I suppose Consul Carroll did it.

For other details on the irrigating system, see Professor Alfonso's treatise on "Idraulica Agraria," sent to the Department.

VINCENT LAMANTIA,
Consul.

UNITED STATES CONSULATE,
Catania, Italy, September 18, 1889.

PORTUGAL.

CAPE VERDE.

REPORT BY CONSUL PEASE, OF SANTIAGO.

The subject of irrigating arid and cultivated lands in this colony is not varied or extensive enough to form the basis of a report such as requested.

Nature has been so unbounteous in her supply of fresh water to the Cape Verde Islands that there are no lakes, rivers, ponds, or large streams except during the rainy months, which are August, September, and part of October. But there are many springs on the islands of St. Antonio, St. Iago, and St. Nicholas, issuing through the rocks at the base of the mountains, in the bottoms of the deep valleys and ravines. It therefore became necessary that the inhabitants should have settled near a spring; yet about half the towns and villages on these islands are so remote from fresh water that all their supply is brought from 1 to 3 miles on donkeys or the heads of women.

It would be difficult to obtain any precise information as to the quantity of land under irrigation, as there are no reports or statistics on such a subject. Yet from observation, and information received from some landholders, I should not underrate the areas by stating that the only lands receiving irrigation during the dry season, which is from November to August, are a few patches of flat ground in the valleys below the level of the springs, cultivated as "garden plots."

The mode of irrigating is by making with a hoe (the principal agricultural implement used in this colony) a number of small trenches leading from the springs through the cultivated grounds.

HENRY PEASE,
Consul.

UNITED STATES CONSULATE,
Santiago, August 14, 1889.

SPAIN.

REPORT BY CONSUL PEREZ, OF SANTANDER.

It has been the common aim of the Spanish people, as well as those patriotic and enlightened rulers who have guided the destinies of the nation with a true devotion to the public welfare, to give constant aid and all possible impulse to everything that tended to the protection and development of the water-supply system.

The hydraulic works for irrigation carried out in Spain in ancient and modern times, although not yet completed to all the extent of which this country admits and even requires, show bold conceptions; they are in many cases magnificent practical monuments erected by intelligent, active minds, who thus have endowed large districts with the fruitful and lasting germ of the luxuriant life there enjoyed by past and present generations.

The treatise on "Water and Irrigation" ("Aguas y Riegos," two volumes), which, as instructed by circular of May 2, 1889, I have the

honor to send the Department of State with the present report, will, I am confident, afford useful information to the special committee appointed by the United States Senate to investigate into the matter of irrigation as practiced in Spain, and perhaps excuse diverse omissions I may make.

While I respectfully call the attention of the Department to the said book, saying that it is the only work published in this country which in every direction treats the subject in a reliable and exhaustive manner, I beg to mention that its author, Mr. Andrés Llauradó, is the chief forestry engineer for the district of Madrid, and a qualified authority both at home and abroad. He recently, in the name of the Spanish *ministerio de fomento* (the department embracing public works, agriculture, industry, and commerce), took part in the discussions held at the International Congress of Paris on the utilization of the water of streams. His views upon the subject "*de l'avenir des canaux d'irrigation*," a remarkable essay, met the approval of eminent foreign scientific men.

Mr. Llauradó's work, "Water and Irrigation," contains an elaborate historical and technical description of the canals and reservoirs built in Spain; also useful suggestions, resting upon his practical observations concerning construction, financial and economic results, and the best means to secure the success sought in enterprises for irrigation.

First of all I will now point out the prominent conclusions arrived at by Mr. Llauradó, namely:

It is an axiom that in northern countries irrigation increases the product of cultivation, especially in summer. In southern countries irrigation becomes absolutely necessary, whether to remedy drought or to overcome the consequences of unequal rainfall.

Reservoirs become absolutely necessary in Spain to store up water during the time there is rain, in order that the decrease produced in streams, just when agriculture is most in want of it, might be restored.

Irrigation undertakings must be divided into two different classes:

1. Irrigation works which can be achieved by single individual effort.
2. Irrigation schemes which necessitate the interposition and subsidies of the Government.

Private activity, considered from a financial standpoint, will be able to accomplish irrigation schemes, provided the rate which consumers pay for water covers the expense of working them, the amount of interest corresponding to capital invested and a fair profit. Otherwise the business must result in failure for private concerns, while, though it can not be absolutely asserted, it is advantageous for the Government, whose ample, unlimited means of action allow them to balance loss with profit.

What now is met with at the Canal Imperial de Aragon and at the Canal de Urgel, under direct management of the public administration, clearly evidences that assertion. The construction of the first-mentioned canal cost the Government about 20,000,000 pesetas (\$4,000,000), and since the reign of Carlos III, when it began to be worked, up to our days, the immediate, direct net produce earned by the administration aggregates the sum of 37,000 pesetas (\$7,400) annually, a very meager yield in proportion to the capital invested. But the business, however, far from being ruinous for the state, has largely compensated the outlays by creating great sources of wealth which deliver up to the public treasure a good part of their income.

It must not be overlooked that in order to render the utilization of water schemes mutually advantageous to companies and farmers, the irrigation tariff must be rated cheap.

The modest yet mighty sphere of private spirit is able to achieve with success many works in totality superior to the limited number of enterprises due to the initiative of the Government.

That does not mean that the Government should be allowed to monopolize these kinds of undertakings.

But the administration can promote such irrigation business as private companies may undertake by affording facilities to individual action, by making public the hydrological data, the investigation of which is not consistent with private initiative, and by framing accurate statistics on the rights for use of available public water.

As regards the great works of canalization, the Government ought to undertake the construction for its own account, and when they are finished cede them on fair terms to the irrigation syndicates, reserving to itself the right of superintendence and protection, in order that the sacrifices made by the people may not prove fruitless.

The Spanish peninsula extends approximately over eight latitudinal and upwards of twelve and one-half longitudinal degrees; its periphery measures 3,300 kilometres; the surface of its soil comprises about 50,000,000 hectares (123,500,000 acres), with elevations exceeding 3,500 metres above the level of the ocean, vast table-lands, deep valleys, and nearly 2,000 kilometres of seacoast, extending along four slopes washed by different seas and facing different cardinal points of the globe.

The contrasting conditions of climate enjoyed according to local circumstances can well be imagined; they are so manifold that in this sense, rather than a mere peninsula, Spain comprises by itself a vast continent joined to the rest of Europe through the mountain range of the Pyrenees, and partakes the scale of subtropical up to subalpine temperature, with burning summers, as in the Sahara Desert, or glacial winters, as in Scandinavia. A glance at the hereto-appended summary of meteorological observations (inclosure No. 1) gives a fair idea of the physical consequences which arise in various regions.

In the qualities of the soil all gradations exist, from the hardest and most compact clay to that of the most loose and movable siliceous nature, in all possible shapes, the evenest as well as the steepest and most rugged. It also differs in depth, from the shallowest and most naked soil up to the most covered with vegetable layers; and as to the hygrometrical conditions, from extreme moisture to the most complete dryness, from the least fitted to irrigation and to such as is perpetually condemned to receive no other water than from rainfall.

Of the total area of Spain (50,000,000 hectares) 40,000,000 hectares are cultivated for crops and pastures; about 2,000,000 thereof are benefited by irrigation.

Among other peculiar features common to the north coast of Spain, the provinces of Santander, Oviedo, Biscay, and Guipuzcoa, in which this consulate and its respective agencies of Gijon, Bilbao, and San Sebastian are located, partake of the most frequent and greatest rainfall in any part of the Spanish peninsula or in Europe.

I quote what Mr. Llauradó says, referring to the above-mentioned provinces:

On account of the great moisture, the air being almost always in a state close to saturation, ordinarily no other farming grounds but the meadows require a supplementary irrigation. In comparatively dry summers, however, some orchards will be irrigated, principally on alluvial soils of new formation, where the underlying stratum, consisting of loose pebble stones, allows an easy permeability.

Permanent meadows constitute the main basis of the agricultural wealth, for they are calculated to supply food for 400,000 heads of horned

cattle and a good number of horses and sheep, besides, as refers only to the province of Oviedo, and nearly equal proportionate ciphers are applicable for the remaining three provinces, especially for Santander.

In order to examine the cultivation of meadows as it is practiced here, we must suppose them divided in two groups, namely, irrigated and not irrigated meadows. The first ones are generally lying on the declivities or in the valleys, in the neighborhood of some spring or brook the water of which may be easily drained; and the last-mentioned meadows occupy the table-lands on the tops of mountains and all such places not much accessible for irrigating them by artificial means, which enjoy no other irrigation but that imparted by eventual rains.

The irrigated meadows, in their turn, form two groups, in the first of which are included those the products of which are consumed by cattle on the meadow itself, the summer harvest excepted, this being mowed and stored for stable food. In the second group are comprised the meadows the produce of which is mowed and cattle fed therewith when yet green, and which furnish, besides, the summer harvest, like the meadow lands of the first group. In these irrigations last during all the year, and are only discontinued as long as the cattle are kept within the stable, this being done in the months of April, September, and October, on fine days in winter, when tardy frosts are feared, and during 20 to 30 days before harvesting the hay.

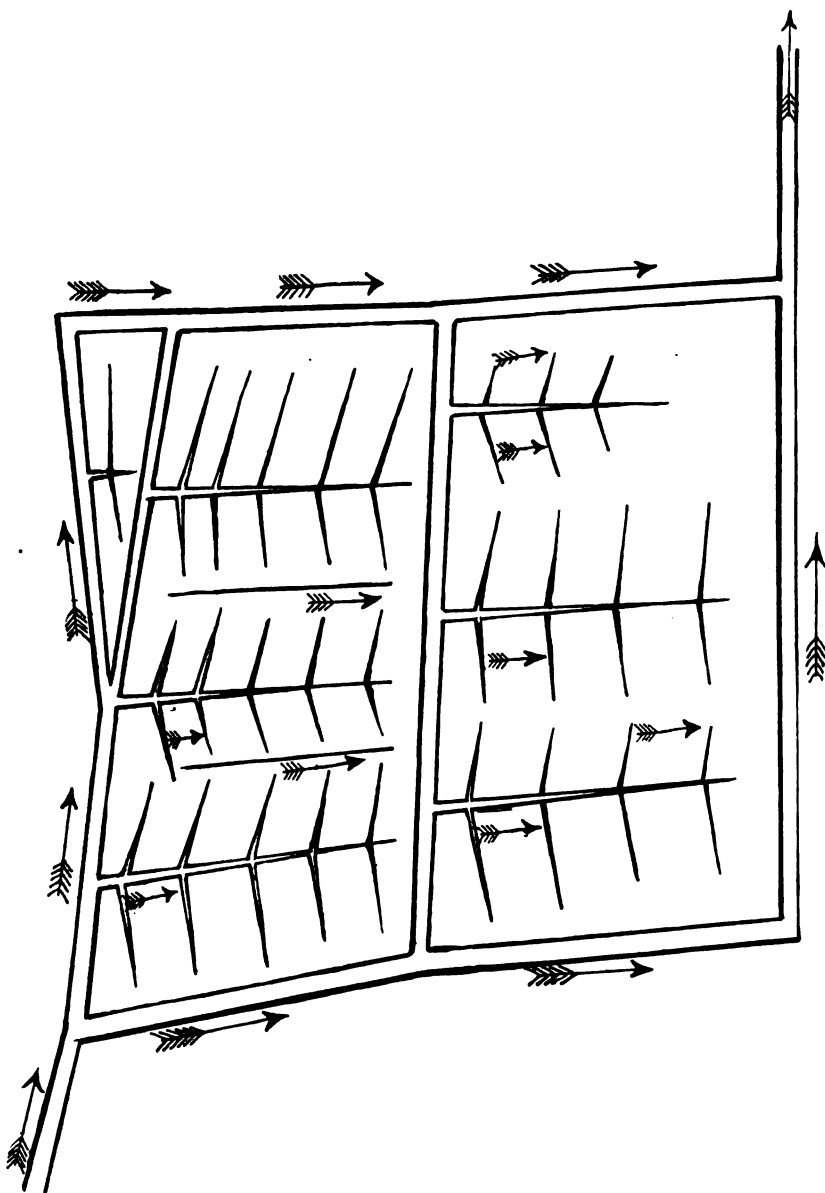
Not irrigated meadows, in spite of the moist climate, yield considerably less than the irrigated ones, irrigation being, therefore, indispensable if it is desired to obtain abundant pasture and hay.

The remark has already been made that the water used for this kind of cultivation is either drawn from brooks or from little perennial springs, as well because of the continuity and facility of their utilization as on account of the difficulties met with in the drainage from streams, the most part thereof offering deep beds and an excessive slopiness.

The system for irrigation of meadow lands most commonly applied in these provinces is that denominated "irrigation by inclined channels," or also "spike channels" (*riego por requeras inclinadas* or "*requeras en espiga*"). The distribution channels are devised nearly in the sense of the greatest slopiness of the ground; the irrigating channels connect with them and spread out to right and left. A rapid sectional change takes place in the distribution channels at the point where they separate into branches with the irrigating channels. The last mentioned channels, by having a gradually narrowing section from their parting point down to the opposite end, pour out the water by getting inundated. Another contrivance is also combined with this briefly described distributive system, which consists of collecting channels, called "*azarbes*," dug on the natural lines of junction on the meadow ground, terminating in an outlet channel. Sometimes, when the extent of the meadow is not considerable, or when the quantity of water available is but small, the collecting channels are changed into new feeding channels for the supply of other lots situated farther down.

Within the four provinces above named discrimination of three different climates and regions must be made, depending from situation whether on the seashore, inland valleys, and mountains.

The climate on the seashore is mild; orange trees can thrive in the open air. In the valleys the climate is fresh; there orange trees, as also grape vines, only thrive in sheltered places. The climate on the mountains is cold; they generally in winter are covered with snow. Here lies the center of the Cantabrian Mountains, a branch of the



SPIKE CHANNELS.

Pyrenean mountain range, with lofty summits, some of them as high as 2,678 metres above the level of the sea. The highest temperature at the inland valley of Cabuerniga, Santander, during a period of 3 years (1872-'74), as recorded by the forestry engineer, Mr. Luis Calderon (inclosure No. 2), was 48° heat in the sun, 39° in the shadow, and the lowest, which, like the other extreme temperature, very seldom occurs, was 4° below zero. Many years the temperature never exceeds 0°. When the thermometer points out 8° or 10°, water generally falls on the mountain pastures lying highest, called "puertos" or "harbors," in the shape of snow.

The forestal and cattle-raising industries are the most genuine and prominent riches in these provinces, especially in Oviedo and Santander. The structure of the soil, consisting of narrow valleys surrounded by mountains, with varied but for the most part too steep slopes for safe cultivation, it is obvious that agriculture, limited to valleys and flat lands of small extent, can never attain a great development. But in exchange for the forest and cattle interests there is proportionately immense room in the best conditions for success, as the frequent rains and continuous mists covering almost constantly and at all seasons of the year those mountains maintain a most suitable fresh and moist character to vigorous spontaneous vegetation. The communal pasture grounds being abundant and of such good quality, natural meadows, are most of them intended to harvest fodder for feeding the cattle during the time the atmospherical inclemencies hinder a direct grazing. As the period when this occurs is no longer than three or four months in the year, the cattle-raising industry is certainly susceptible of a far greater increase as soon as the meadow lands are more carefully cultivated and larger quantities of hay are produced. With the quantity of fodder indispensable for one head of cattle in other provinces three head will then be fed here, because the period cattle have to be kept housed is much shorter. A permanent keeping in the stall is not advisable unless the absurd principle should be established to abandon the enormous wealth which the beautiful and vast grazing grounds of the high meadows (puertos) represent.

The system now partly prevalent in cattle breeding is, of course, such as arises from the local conditions. In the western region horn cattle are raised until two years old, whereupon farmers in the eastern region and on the seashore devote themselves to feed the same up to full growth. In the first-mentioned region natural as well as high meadows (puertos) are abundant, while in the other parts that kind of meadows are scarce, and consequently cultivation meadows become necessary.

One should think that in the Cantabrian coast, in one of the rainiest countries of Europe, the system of drainage, rather than that of artificial irrigation, would often be applied, yet irrigation is here of no little importance, mainly to obtain natural meadows and repair the irregularities of meteoric water used for other cultivations.

Irrigation is most frequently made use of here during the months of March and April, when grass begins to shoot up. The soil is left altogether inundated when strong frosts are feared, in order that the cover of water might protect the soil against the consequences of frost or ice. In normal years artificially irrigated meadow lands produce greater harvest than those called "praderas de secano," or "dry land meadows," but in exceptional years of drought the irrigated meadows are the life-boats wherein farmers save their cattle.

Milk, butter, and cheese, all of an exquisite natural flavor in these provinces, can be affirmed to have no rival of higher standard in the

world. It is obvious to reveal the secret of such excellent qualities, which consist in nothing else, besides a good cattle race, but the conditions of plenty of pure air and nutritive aromatic pastures. The cow breeds called of "Tudanca" and of "Campoo," in the neighboring districts of Cabuerniga and Regnosa, respectively, Santander, and the "Asturian" race, province of Oviedo, justly enjoy great renown.

For centuries the mountain woodlands of Santander have been providing with superior timber (oak) the Spanish navy and merchant shipyards, also (beech) cooperies for preparing barrels or casks for wine, and wheat-flour exportations to the Antilles. They have scarcely escaped the total devastation that has been the fate of public forests in Spain. The cause of such blind destruction is partly imputed to the selfish toleration of "caciquism;" in Spain the name of "cacique" is given to the electoral agents whose personal prevalence in the districts controls the votes, which, leaned upon, a centralizing tendency so deeply disturbs the sound organs of political and social life in this country, its pernicious effects acting the more oppressively upon the rural localities, where it causes a great apathy towards the advancement of affairs of common interest and the preservation of common property. The planting of trees to replace those consumed or cut from the parish forests was compulsory for all citizens who enjoyed the rights to use the same. That duty is completely neglected, though it has not been repealed; it is not enforced as it ought to be. All political factions, not one excepted, profess "caciquism" to be the most dreadful scourge that hinders the proper efficacy and functions of laws and that requires an urgent eradication. It happens, however, with "caciquism" unfortunately the same as with certain infirmities afflicting the human nature; all physicians know a sure remedy to cure them, but the patients' health never improves. As "caciquism" avows to be the promoter and guardian of common interests and also becomes the lawful adviser to the central power in matters relating to public administration, many wrongs are ascribed to the Government in an unjust and thoughtless manner of which it is merely a harmless and unconscious instrument.

I have thought it pertinent to make some digressions on the circumstances attending agriculture and cattle raising—those two branches which form the great wealth of the mentioned provinces—because of their being so closely connected with irrigation. The book "*La agricultura y la administracion municipal*" will more fully illustrate with a practical work, which precisely refers to experience drawn from a municipal district in the province of Santander, the obstructions "caciquism" opposes in Spain to the regular and progressive course of said interests. All the advantageous and laudable endeavors of a man of high character and intelligence who during 4 consecutive years was at the head of the municipality, exclusively devoting himself most eagerly to ameliorate the public interests, were soon demolished by "caciquism," with whom he had all that time continually to fight tenacious struggles.

On the whole, the geological and climatic conditions in this northern part of Spain keep the greatest resemblance with the counties comprising the "*wealden formation*" in the southeast of England, such as Kent and Sussex.

An agent which considerably modifies the damp character of this climate is the south wind. It acts like an enormous sponge, to absorb the humidity, and as a natural stove, where both the air and the soil are speedily dried up. The atmosphere acquires then such transparency

that scarcely any gradual lines or shadows of varying distances on the horizon are perceived. It is peculiar to the south wind that immediately it ceases to blow it is generally followed with rain, and that while it is blowing on the coast rain will most likely be falling on the elevated plateau of Old Castile. The winds which prevail longest in the year come from the west-northwest, succeeding the periods from the south. The east-northeast winds are those blowing in summer until September or October, when they maintain clear, dry weather for longer time.

In the provinces of the north, adjoining those where this consulate and its agencies are situated, irrigation by artificial means is practiced more extensively at Leon, which borders on its northwest side with Santander and Oviedo. The Esla Canal irrigates there about 13,000 hectares (32125 acres). When its construction began (1859) the estimates amounted only to 625,000 pesetas (\$126,000), but 10 years later (1869) the sum of 3,250,000 pesetas (\$650,000), had been expended. It carries a quantity of 6,480 cubic metres water per second. This canal was built by grant to a foreign private company. According to agreement the annual rate farmers have to pay for water varies from 19.45 pesetas to 97.27 pesetas (\$3.89 to \$19.45) for each hectare of land irrigated. Notwithstanding the yearly aggregate cashed by the company has been 8½ per cent. on the capital invested, it does not produce sufficient to pay the interest to capital, the expenses of maintenance, management, and of interest necessary for amortization. The company met with some embarrassment, perhaps, by not having secured through a formal written engagement how far they had to rely upon consumption of water. Until a year when extreme drought prevailed in the country the attitude on the part of many farmers to subscribe for the use of the water of this new canal was quite reluctant, but then they obtained a practical conviction of the positive advantages derived from artificial irrigation to supply the absence of rain.

On the vast plateau of Old Castile the Canal de Castilla crosses a distance of 208 kilometres from Alar del Rey, Santander, dividing in two branches at El Serron, Palencia; one of them, the Canal del Sur, 54,432 kilometres long, down to Valladolid, and the other, the Canal de Campos, 78,929 kilometers long, to Medina de Rioseco, the center of cereal production in the north, called for this reason by Spaniards "el granero de España," or "the corn barn of Spain." The section of the Canal de Castilla from Alar del Rey to El Serron takes the denomination of "Canal del Norte," and is 74,431 kilometres long.

The Canal de Castilla is an important water road for transportation, navigated by barges carrying each about 33 tons; the water of it serves also as a motive force for a good number of large mills and factories. But the same is scarcely used as a means of artificial irrigation. Its most noteworthy works are seven locks on the Canal de Campos, twenty-four on the Canal del Norte, and seventeen on the Canal del Sur. On the Canal del Norte section the canal carries 447 cubic metres water per second, being distributed between the two branches in the proportion of 279 cubic metres to the Canal del Sur and 168 cubic metres to the Canal de Campos. The uppermost part of the canal in the last-mentioned section is 15.55 metres wide at the surface of the water 11.66, and at the bottom of the canal 5.83 metres wide; it has a depth of 1.93 metres.

The towage-path along the canal measures 3.33 metres width on places where the earth had to be cut off, and 4.44 metres at the embankments.

The Pisuerga and Carrion, affluents of the river Duero, are the feeders of the Canal de Castilla, the construction of which began in the middle of the last century, was interrupted, and reached its completion during the reign of Queen Isabel II.

In normal years the want-of moisture necessary to the growth of most cereals—wheat, barley, rye, etc.—seems not to be much felt on the boundless-looking cornfields of the northern provinces of Castile. The arable surface of the soil is deep and fertile, though the monotonous perspective of vast plain land impresses the mind with aridness, seeing that it is almost completely denuded by trees everywhere, for the prejudice is most prevalent there among cultivators "that trees are only good for sparrows to build their nests on and as places of shelter for the voracious winged enemies of plantations."

During the Crimean war the shipments of wheat flour from Castile made at the port of Santander amounted to enormous quantities. An enthusiastic fever existed then throughout Castile. The boasting phrase, "*Agua y sol y guerra en Sevastopol*" ("Water and sun, and war at Sevastopol"), whereby Castilian farmers expressed their prosperous situation in those years, was so generally pronounced and repeated that it became a proverbial sentence. A great number of flour mills were erected on the canal, and the largest possible extent was given to the production of cereals. Those exceptional, incidental causes by which agriculture was favored have passed long ago. Farmers in Castile devote their care not only to cereals but also to extend the grape-vine plantations, and must adopt all improvements in modern agricultural progress if they will keep pace with the cheap production of other countries. Irrigation will be, of course, a means to the profitable result of a varied cultivation.

The province of Logroño, bordering on the Basque province Alava, is one of the agricultural districts where great benefits are obtained through artificial irrigation that makes it very productive in all kinds of fruits and vegetables; it is the richest orchard and kitchen garden in the northern region of the river Ebro, the source of which is at Fuentibre (Fons Iberus), near Reynosa, Santander. This river becomes navigable at Saragossa, supplies water for the Canal Imperial, and some others of the most important irrigating canals, and no other river in Spain is more used for irrigation; the advantages it affords to agriculture are considerable.

At Logroño and the neighboring districts, known all under the denomination of "*La Rioja*," good wine is obtained and mostly exported to France and also shipped to other countries by Bilbao and Santander. Fruits and vegetables (capsicum, tomatoes, peas, etc.) are prepared in cans in important quantities for home and export consumption.

The practical and wise laws founded by the Arabs during their domination in the south of Spain, in the provinces of Valencia, Murcia, and Granada, maintained there more specially by careful tradition, are the basis of the new laws framed for all irrigating corporations, who will enjoy certain privileges. These privileges consist substantially in the right that when as prescribed they unite in "*Sindicatos*" or syndicates, they can appoint their own independent courts, all proceedings being public, verbal, and the decisions of these independent courts or water juries (*jurados de aguas*) inappealable.

In Leon such syndicates exist, so in Logroño, but in none of the above-mentioned provinces of the north, where, for the reasons I have explained, artificial irrigation exhibits an individual, isolated aspect.

Engineers in the construction of some of their great hydraulic contrivances perhaps only observe and copy the works of nature. There are no lakes formed by rivers in Spain to collect water for further distribution in "natural deposits;" to supply the same, on suitable elevated places, sometimes on the mountain gorges, reservoirs, called "albuheras" or by the more modern name "pantanos," are built where the water is stored up. "Acequia" (as many words of Arabic source) means exclusively "irrigation canal."

In Valencia farmers have inherited with the valuable irrigating system of the Saracens also their good practical habits for agriculture. There they know what great value water involves; they always carefully look that the ground be well leveled in order that the water coming both from canals and from rainfall is equally beneficial to the plants, because otherwise some parts of the soil will become covered with water while other parts remain dry, and in some others water will carry away the humus, the salts, and oxides, the richest elements contained in manure to aid vegetation. Nobody knows better than they how to retrench the flowers and buds when the plants are too overcharged, as they are aware that a smaller number makes fruits get ripe earlier and improves the quality; nobody else knows better than those farmers how to select the precocious ears, one by one, with the purpose of ameliorating the species and accelerating the period for ripeness. The Valencia farmers remain constantly near their plantations, and through artificial irrigation they realize in that climate an abundant and incessant crop of rich products.

CLDOMIRO PEREZ,
Consul.

UNITED STATES CONSULATE,
Santander, November 7, 1889.

[Inclosure 1 in Consul Peres's report.]

Summary of meteorological observations made in the Peninsula (Spain), mostly during the decennial period of 1865-1874.

Places.	Years.	Average barometrical height.	Average annual barometrical oscillations.	Average temperature.				
				Winter.	Spring.	Summer.	Autumn.	Year.
		meters.	mm.	°	°	°	°	°
Vergara.....	1867-1872	748.9	32.4	7.9	12.2	20.0	14.8	13.9
Bilbao.....	1865-1873	762.6	34.0	9.6	14.1	20.7	15.8	15.0
Oviedo.....	1865-1874	742.9	34.9	7.9	11.7	18.2	13.8	12.9
Santiago.....	1865-1874	736.6	38.5	8.2	12.0	18.5	13.7	12.1
Oporto.....	1866-1874	755.0	32.2	10.1	14.8	20.9	15.8	15.5
Coimbra.....	1865-1874	751.0	32.3	10.5	14.8	21.2	16.8	15.7
Lisbon.....	1865-1874	755.1	34.9	10.7	14.6	20.9	16.7	15.7
Salamanca.....	1865-1874	693.5	30.6	4.8	10.4	20.5	12.5	12.2
Valladolid.....	1865-1874	701.4	30.2	4.1	10.7	20.2	12.1	11.8
Burgos.....	1865-1874	688.5	30.2	3.6	9.7	18.1	11.1	10.7
Soria.....	1865-1874	671.2	28.6	4.0	9.9	20.0	12.0	11.4
Saragossa.....	1865-1874	671.2	28.6	7.0	14.6	24.0	15.5	15.2
Huesca.....	1865-1874	671.2	28.6	4.8	12.1	22.1	13.2	13.2
Barcelona.....	1865-1874	761.9	35.2	9.8	14.6	22.4	17.5	16.3
Palma (Balearic Islands).....	1865-1874	762.9	29.2	11.5	16.1	25.0	19.5	18.0
Valencia.....	1865-1874	761.5	32.7	10.8	15.6	22.9	18.7	17.2
Alicante.....	1865-1874	760.9	30.4	11.6	16.1	24.7	18.9	17.8
Murcia.....	1865-1874	758.2	30.9	10.8	16.2	24.9	19.1	17.8
Albacete.....	1866-1874	702.1	26.4	5.6	12.0	22.6	15.4	13.6
Ciudad Real.....	1866-1874	709.1	27.9	7.7	14.8	25.2	16.9	15.9
Madrid.....	1865-1874	706.8	31.7	5.2	12.5	23.8	13.7	13.7
Jaen.....	1867-1872	712.8	27.2	8.3	15.3	25.4	16.2	16.1
Granada.....	1865-1874	704.9	26.6	7.0	13.4	23.4	15.2	14.8
Seville.....	1865-1874	761.9	28.9	11.8	17.7	23.1	20.6	19.6
Carla.....	1867-1874	762.2	25.9	12.5	16.1	22.6	18.4	17.3
S. Fernando (Cadiz).....	1867-1874	761.2	27.7	12.3	16.4	23.4	18.6	17.7
Malaga.....	1878-1880	762.8	12.6	12.7	17.7	26.3	20.2	19.3

Places.	Years.	Temperature.		Average rainfall.				
		Average maximum.	Average minimum.	Winter.	Spring.	Summer.	Autumn.	Year.
		°	°	mm.	mm.	mm.	mm.	mm.
Vergara.....	1867-1872	40.2	- 6.4	425	346	227	321	1329
Bilbao.....	1865-1873	39.8	- 2.2	366	806	183	864	1218
Oviedo.....	1865-1874	32.8	- 3.4	260	263	154	251	937
Santiago.....	1865-1874	34.9	- 2.0	634	430	156	518	1748
Oporto.....	1866-1874	34.4	+ 0.2	587	410	89	423	1500
Coimbra.....	1865-1874	38.4	+ 0.0	287	246	75	246	854
Lisbon.....	1865-1874	34.5	+ 2.2	289	180	29	282	691
Salamanca.....	1865-1874	38.5	- 9.2	53	76	43	73	250
Valladolid.....	1865-1874	38.6	-11.0	75	89	48	92	394
Burgos.....	1865-1874	35.4	- 9.9	109	176	100	153	537
Soria.....	1865-1874	36.0	- 9.0	139	187	127	164	617
Saragossa.....	1865-1874	41.8	- 7.6	68	106	58	101	233
Huesca.....	1865-1874	36.6	-10.0	120	179	103	214	616
Barcelona.....	1865-1874	32.3	+ 0.1	110	152	107	228	607
Palma (Balearic Islands).....	1865-1874	37.0	+ 1.2	116	164	42	172	435
Valencia.....	1865-1874	38.2	- 0.9	84	89	42	242	457
Alicante.....	1865-1874	39.2	- 2.7	104	127	48	167	441
Murcia.....	1865-1874	40.3	- 3.2	87	105	31	111	334
Albacete.....	1866-1874	36.7	- 8.9	67	117	57	93	334
Ciudad Real.....	1866-1874	42.3	- 6.7	110	89	81	86	316
Madrid.....	1865-1874	39.9	- 7.0	101	110	51	120	382
Jaen.....	1867-1872	39.5	- 2.9	225	170	40	170	605
Granada.....	1865-1874	35.6	- 2.4	151	145	27	144	467
Seville.....	1865-1874	46.5	- 1.1	108	83	21	93	295
Carla.....	1867-1874	34.3	+ 1.6	238	151	11	168	566
S. Fernando (Cadiz).....	1867-1874	37.4	+ 1.2	372	212	19	237	890
Malaga.....	1878-1880	41.0	+ 2.5	188	146	9	204	596

Summary of meteorological observations made in the Peninsula (Spain), etc.—Continued.

Places.	Year.	Average number of rainy days.					Average of days—			Winds prevailing (covered).
		Winter.	Spring.	Summer.	Autumn.	Year.	Clear.	Cloudy.	Covered.	
Vergara	1867-1872	43	47	37	45	172	72	112	182	NW.
Bilbao	1866-1873	46	43	33	48	166	78	128	159	NW.
Oviedo	1865-1874	40	44	30	42	156	54	151	160	NE.-SW.
Santiago	1865-1874	52	43	24	43	162	85	150	180	NE.-SW.
Oporto	1866-1874	40	31	12	26	109	107	117	141	SW.
Coimbra	1865-1874	43	38	20	24	135	73	190	102	-----
Lisbon	1865-1874	44	31	9	30	114	113	177	75	N.
Salamanca	1865-1874	18	23	10	21	72	125	180	111	NW.
Valladolid	1865-1874	19	24	13	22	77	87	148	130	NE.
Burgos	1865-1874	24	30	19	32	105	84	144	137	NE.
Soria	1865-1874	22	28	18	24	92	102	170	93	NE.
Saragossa	1865-1874	14	22	13	16	67	120	84	81	NW.
Huesca	1865-1874	19	23	15	22	80	162	136	67	NW.
Barcelona	1865-1874	17	21	14	21	73	121	137	107	S.
Palma (Balearic Islands)	1865-1874	24	19	9	23	54	158	153	54	S.S.W.
Valencia	1865-1870	14	14	6	14	48	252	59	54	W.
Alicante	1865-1874	11	14	6	13	44	136	191	38	S.E.
Murcia	1865-1874	18	20	8	18	64	133	139	93	S.S.E.
Albacete	1866-1874	14	17	8	14	54	134	100	131	S.E.
Ciudad Real	1866-1874	18	20	8	14	60	193	85	87	W.
Madrid	1865-1874	30	27	13	25	95	133	171	61	NE.
Jaen	1867-1872	25	24	7	20	76	146	155	64	W. NW.
Granada	1865-1874	23	26	7	22	78	195	68	102	SW.
Seville	1865-1874	22	18	4	15	59	201	115	49	SW.
Carifa	1867-1874	29	20	3	19	71	194	91	80	E.
S. Fernando (Cadiz)	1867-1874	36	26	7	28	97	97	199	69	-----
Malaga	1878-1880	11	11	2	7	34	167	150	48	SE.-WNW.

[Inclosure 2 in Consul Perez's report.]

Summary of meteorological observations made in the Cabuerniga valley (Santander, Spain) by the forestry engineer, Mr. Luis Calderon, during the years 1872, 1873, and 1874.

Months.	1872.			1873.			1874.		
	Rain days.	Quantity of rain.	Average temperature.	Rain days.	Quantity of rain.	Average temperature.	Rain days.	Quantity of rain.	Average temperature.
January	22	mm. 265.70	° 10.64	11	mm. 53.55	° 11.17	8	mm. 560.0	° 11.42
February	6	42.20	13.72	14	203.55	9.37	9	870.0	11.46
March	12	56.05	13.64	10	169.70	13.71	7	59.00	12.54
April	10	175.25	15.37	17	183.20	13.10	11	357.50	16.50
May	12	97.65	15.13	6	92.10	15.83	5	96.60	17.58
June	7	38.40	20.17	12	97.76	20.73	15	148.40	19.60
July	10	87.85	23.22	9	52.40	23.87	6	100.80	23.25
August	11	44.75	23.45	4	45.40	23.71	2	5.34	22.80
September	6	15.00	22.57	4	36.60	21.93	7	54.80	31.63
October	18	191.80	15.09	11	144.60	17.32	4	106.80	17.71
November	12	160.90	13.17	11	54.05	13.47	11	273.40	13.67
December	9	106.50	11.32	2	3.60	9.29	20	564.80	8.29
Total	135	1,223.00	-----	110	1,213.75	-----	105	1,931.00	-----

SPAIN.

REPORT BY CONSUL INGRAHAM, OF CADIZ.

I can not learn of any maps or works on the subject, though the latter may exist, translated from the French, but are regarded as merely theoretical and of no interest or value to a people who have from the time of the Moors, and perhaps of the Romans, carried on practical systems of irrigation chiefly in the provinces of Murcia, Valencia, and Granada, and to a lesser extent in western Andalusia.

In these provinces, especially Seville, which is watered by the Guadalquivir, whose valleys are rich not only in corks, grains, but in olives, oranges, palms, grapes, and other semi-tropical fruits, ditches are dug through the lands and fed from the river, and in other localities the irrigation is done by a sort of water-raiser from wells, called norias, consisting of a chain of buckets going over and over as they come up from the well, filling and emptying by the operation and propelled by a blinded animal, a horse, cow, ox, or mule, going round and round, and kept within the circle of the noria by a pole running from the head of the animal to the pivotal post. Thus secured he goes alone all day long around the circle without a driver or guide. In some cases a steam engine is in use among large properties, but the noria is of great antiquity.

In Damiel, La Mancha, 3,000 norias are used only in summer, and the same exist generally throughout Spain.

In Lorca, a town near Carthagena, where the land is salty and the river overflowed, an enormous dam has been built in recent years to retain the water.

As no statistics are published I am unable to reply to some inquiries of the circular, but it is believed that the difference between irrigated and non-irrigated lands is as 1 to 25 in value.

There is no government system or control custom regulating all as it did in the time of those masters of irrigation, the Moors. For instance, at Granada a sort of court, called the "water court," has existed by the customs of centuries to pass on all questions of irrigation and rights between owners, and this court is regarded as high authority, dispensing exact justice and enjoying a reputation like none other in Spain. It is organized from custom; it sits at certain times at the Alhambra to hear causes, as it has done since the medieval ages, its members coming on mules or horseback, and alighting before the bench provided for the hearings.

In one of the towers of the Alhambra a bell rings at different times of the night to indicate the flow of the waters of the Xenil and the Darro, which have their confluence at this point and irrigate the vast Vega of Granada.

In this section I am not able to give the names of any experts on irrigation, as in this consular district the operations are limited as above described, but I would refer to Mr. Langdon, of Huelva, engineer of the Pio Tinto mines, who once furnished me an interesting paper on the teredo, a worm attacking submerged wood, and in Cadiz, Señor Don José Maria Conte, a distinguished writer and interested in agricultural subjects.

DARIUS H. INGRAHAM,

UNITED STATES CONSULATE,

Consul.

Cadiz, August 13, 1889.

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